IN THE

Supreme Court of the United States

OCTOBER TERM, 1975

No. 75-1589

ALCOR AVIATION, INC.,
Petitioner,

versus

RADAIR INCORPORATED,
Respondent.

PETITION FOR A WRIT OF CERTIORARI TO THE UNITED STATES COURT OF APPEALS FOR THE NINTH CIRCUIT

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Petitioner prays that a Writ of Certiorari issue to review the judgment of the United States Court of Appeals for the Ninth Circuit affirming a judgment of the United States District Court for the Western District of Washington, a Petition For Rehearing With Request For Rehearing En Banc filed by Petitioner on October 9, 1975, having been denied on February 2, 1976 with the Court of Appeals amending its original opinion.

OPINIONS BELOW

In a full trial held to the District Court (Judge Walter T. McGovern), the District Court held Petitioner's United States Letters Patent Number 3,154,060 invalid.

Findings of Fact and Conclusions of Law entered by the District Court on July 31, 1972 is set forth herein as Appendix A, *infra*, pp. 1a through 11a. Judgment entered by the District Court on July 31, 1972 is set forth herein as Appendix B, *infra*, p. 12a. On appeal to Court of Appeals, the decision of the District Court was affirmed. The opinion of the Court of Appeals is officially reported at 527 F.2d 113 (9th Cir. 1975). The slip opinion of the Court of Appeals is set forth herein as Appendix C, *infra*, pp. 13a through 21a. In response to a Petition for Rehearing with Request for Rehearing En Banc, the opinion of the Court of Appeals was amended, (the request for rehearing en banc rejected) and the petition for rehearing denied. The Amendment of Opinion and Denial of Rehearing by the Court of Appeals is set forth herein as Appendix D, *infra*, pp. 22a through 23a.

JURISDICTION

In the United States District Court, Western District of Washington, jurisdiction was conferred by 28 U.S.C. §§ 1338 and 1400. A determination of invalidity of Petitioner's patent was appealed to the Ninth Court of Appeals. The opinion of the Ninth Court of Appeals affirming the lower court was entered on September 10, 1975. Petitioner's Petition for Rehearing with Request for Rehearing En Banc was denied on February 2, 1976. The jurisdiction of this Court is invoked under 28 U.S.C. § 1254(1).

QUESTION PRESENTED

Did the Court of Appeals for the Ninth Circuit err in failing to properly apply secondary considerations in determining that the method claim of the present invention was obvious? The secondary considerations include the following:

1. Long felt but unsolved need in the industry;
2. Previous attempts by many highly skilled individuals in the field to solve the problem;
3. Teaching by the industry away from the present invention;
4. Immediate acceptance of the invention by the industry;
5. Praise for the invention by the industry; and
6. Most importantly, instantaneous commercial success throughout the industry.

There is a conflict in the decisions of the Courts of Appeals concerning the treatment of secondary considerations, such as long felt need and commercial success, in determining the proper standard of obviousness. In the decisions of the Fifth Circuit, Tenth Circuit and Court of Customs and Patent Appeals, considerable emphasis is given to secondary considerations. The decisions of the Fourth Circuit and Eighth Circuit, while stating the principles of secondary considerations in determining obviousness, almost always find the patent in question to be obvious. The Second Circuit, Seventh Circuit and Ninth Circuit each have two conflicting lines of

decisions. The line of decisions to support the opinion is normally cited without distinguishing the conflicting line of decisions. The First Circuit, Third Circuit and Sixth Circuit take a middle position when applying secondary considerations to determine obviousness.

THE LAW INVOLVED

A Writ of Certiorari should be granted to resolve a conflict between the Circuits when applying secondary considerations to determine obviousness of an invention. Rule 19(1)(b), Rules of the Supreme Court of the United States.

The law involved is Art. I, § 8, cl. 8, The Constitution of the United States of America, which states that:

> "The Congress shall have power to promote the progress of science and useful arts, by securing for limited times to . . . inventors the exclusive right to their . . . discoveries . . . ."

The enabling legislation enacted by Congress which defines what constitutes an invention is codified under 35 U.S.C. §§ 101, 102 and 103. The particular statute involved in the present appeal is 35 U.S.C. § 103, which states the following:

> "A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made."

STATEMENT OF FACTS

This action involves the validity of United States Letters Patent No. 3,154,060 issued to Alf Hundere and assigned to Petitioner. A copy of the patent is set forth herein as Appendix E, *infra*, pp. 24a through 29a. Respondent (Defendant) has admitted infringement if any claim is valid. Only the determination of invalidity of claim 6 was appealed to the Court of Appeals. Claim 6 involves a method of fuel-air mixture control of a piston engine aircraft in flight. Method claim 6 rewritten in independent form is set forth herein as Appendix F, *infra*, p. 30a. Each separate element of the apparatus used to practice the method claim of the present invention is admittedly old.

Since the first flight of an airplane by the Wright brothers at Kitty Hawk, North Carolina, in the early 1900's, the problem of the correct fuel-air mixture control for aircraft has existed. The correct fuel-air mixture control for aircraft powered by piston engines has always been an acute problem. Even with the tremendous growth of the aviation industry, prior to the Hundere invention a need existed for a simple, inexpensive, reliable and accurate method to control the fuel-air mixture of piston engine aircraft.

Prior to the present invention, at least ten known methods were used to determine the correct fuel-air mixture. Some of the methods used include the following:

1. Adjusting mixture by leaning to engine roughness;
2. Adjusting mixture by color of exhaust gases;
3. Adjusting mixture to obtain maximum engine speed;
4. Adjusting mixture to obtain maximum airspeed;
5. Adjusting mixture by use of exhaust gas analyzers;
6. Adjusting mixture by use of fuel flow indicators;
7. Manually plotting a curve of combustion related temperature versus fuel flow to establish the fuel flow for maximum temperature;
8. Setting the mixture control in a detent;
9. Altitude compensation by automatic mixture control; and
10. Adjusting mixture by reference to a brake mean effective pressure (BMEP) indicator.

All the witnesses at the trial agreed that the first nine methods of fuel-air mixture control given above were vastly inferior to the Hundere method. The BMEP method was very complicated and expensive. As a

result, the industry had stopped using the BMEP method prior to Hundere's invention.

Knowledgeable persons in the aviation industry praised the Hundere invention as a major breakthrough in fuel-air mixture control for piston engine aircraft. Engineers familiar with and highly skilled in the art of piston engine aircraft, including, but not limited to, Curtiss-Wright and Pratt & Whitney (manufacturers of large transport and military aircraft engines), Boeing, Douglas and Lockheed (airframe manufacturers), Continental and Lycoming (manufacturers of general aviation aircraft engines) and Beech, Cessna and Piper (manufacturers of general aviation aircraft), recognized the problem of the prior art in fuel-air mixture control. Even with this vast army of experts knowledgeable of the problem for many years, no method as simple, inexpensive, and accurate as the Hundere method was ever suggested by the prior art.

The invention of Hundere utilizes a probe in the exhaust gases to generate a voltage related to the exhaust gas temperature. The voltage drives a meter in the cockpit that indicates exhaust gas temperature (hereinafter referred to as EGT). While manually adjusting the fuel flow and simultaneously observing the meter reading, the pilot determines the mixture setting that gives peak EGT, which is the maximum meter reading obtainable. Thereafter, the pilot can set any desired mixture by observing the meter to determine a change in EGT relative to peak EGT. The entire procedure requires only a matter of seconds, as compared to minutes for the closest prior art. The simplicity and accuracy of the Hundere method as compared to prior methods of mixture control is

astounding. The sheer simplicity and accuracy of Hundere's invention in light of the inaccurate, complex, expensive and/or time consuming prior methods of determining the proper fuel-air mixture is the heart of the patent validity contended by Petitioner. The novelty of Hundere's invention is in the steps used to determine peak EGT. Thereafter, the mixture can be adjusted to give an EGT reading having the desired relation to peak EGT.

Since at least as early as 1942, it was well known in the prior art that peak EGT was the mixture of fuel and air wherein just enough air was present to burn all the fuel. This fuel-air mixture is 0.067 pounds of gasoline per pound of air and is commonly called the "stoichiometric ratio".

The closest prior art consists of the manual plotting of a curve of a combustion related temperature versus fuel flow. Subsequently, the fuel flow may be set relative to the peak temperature established by the curve. Considerable time and effort was required before the proper fuel-air mixture could be determined from the peak temperature. Upon changing the operating conditions, such as a change in altitude, the time consuming procedure had to be repeated. The previously described procedure of graph plotting was known since at least 1942. This method, which is the closest prior art, required a second instrument (the fuel flow meter) not required for Hundere's invention.

As soon as Hundere invented the present method of fuel-air mixture control, reduced it to practice in 1960-1961, and introduced it to the market in 1962, it became an instantaneous commercial success. Despite the ex-

tremely small size of Petitioner compared to the corporate giants in the aviation industry, Petitioner's own share of the fuel-air mixture control business was beyond all expectations. Petitioner's sales of fuel-air mixture control devices on all twin engine piston aircraft was about 61% and about 50% of all single engine piston aircraft (excluding the smaller trainer-type aircraft). To obtain such a high percentage of the market, many aircraft manufactured before 1962 were retrofitted. Petitioner's share of the market was reduced by infringing devices manufactured and sold by the infringers, Respondent being one of the leading infringers.

The share of the market for fuel-air mixture control devices for piston engine aircraft by Petitioner is even more impressive when considering Petitioner's small size. Because of Petitioner's small size, only a minimum of advertising was distributed. Sales by Petitioner were to a very sophisticated class of customers, including Beech and Cessna. This knowledgeable class of customers is not influenced by excessive puffing contained in typical advertisements received from others. However, this sophisticated, knowledgeable class of customers now installs Hundere's invention as standard equipment on their aircraft.

In test flights of the last piston engine aircraft manufactured by Lockheed and Douglas in the 50's, a flying laboratory was provided in the fuselage area of the aircraft. Even though this flying laboratory monitored the EGT by a continuous recording device, no one even suggested the use of Hundere's method of fuel-air mixture control. In fact, the engine manufac-

turer (Curtiss-Wright) taught away from the Hundere method and considered the BMEP method the only effective method of fuel-air mixture control.

All of the witnesses of both parties testified that one of the best prior methods of fuel-air mixture control was leaning to engine roughness. This was very unsatisfactory because it was an inaccurate seat-of-the-pants type of adjustment that could result in the engine backfiring. Despite testimony of witnesses of both parties that leaning to engine roughness was a very poor method of mixture control, far inferior to the patented method, it was the best method available for piston engine aircraft before Hundere's invention with the possible exception of the complicated, expensive BMEP method. By using the method of leaning to engine roughness, the pilot could never tell if he had the proper fuel-air mixture.

In the opinion of the Court of Appeals, it is suggested on 527 F.2d at 117 that the Hundere method was not used because suitable probes for measuring EGT were not available. This is not true. As was brought out in the record, suitable probes for measuring EGT had existed since at least as early as 1942 when the graph plotting technique was first used. The Lockheed and Douglas tests completely rebut this false assumption by the Court of Appeals because Lockheed and Douglas had suitable probes to measure EGT. Furthermore, several infringing devices used exhaust probes substantially identical to the exhaust probes used since 1942 and used in the Lockheed and Douglas tests.

Also, the Court of Appeals falsely assumed that Petitioner was claiming to be the first to recognize the relationship between EGT and fuel-air mixture. Such a relationship had been recognized at least as early as 1942 when the graph plotting technique was first used. When Petitioner pointed this out to the Court of Appeals in Petitioner's Petition for Rehearing With Request For Rehearing En Banc, the Court of Appeals merely deleted that portion of its opinion as indicated in the Amendment of Opinion and Denial of Rehearing attached hereto as Appendix D, *infra*, p. 22a. The portion of the opinion deleted by the Court of Appeals is as follows:

> "Alcor argues that its patent was the first to recognize the theory of fuel-air mixture control by reference to the EGT. The district court found to the contrary and that finding is not clearly erroneous. Knowledge in the prior art as reflected in Diagram I, by itself, adequately supports the judge's finding."

No other changes in the opinion were made even though other portions of the opinion stem from this false assumption.

REASON WHY THE WRIT SHOULD BE GRANTED

Did The Court Of Appeals For The Ninth Circuit Err In Failing To Properly Apply Secondary Considerations In Determining That The Method Claim Of The Present Invention Was Obvious?

The Writ should be granted because the decisions of the Court of Appeals are in conflict with, and contrary

to, the decisions of the Supreme Court of the United States in the cases hereinbelow cited. Further, the various Courts of Appeals are in conflict on the weight to be attributed to commercial success, long felt need, and failure of others, etc., in determining nonobviousness of an invention.

Supreme Court

Judicial decisions by this Court, prior to enactment of the obviousness statute in 1952 and 25 U.S.C. § 103, applying secondary considerations in determining patentability include *Smith v. Goodyear Dental Vulcanite Co.*, 93 U.S. 486 (1876), *The Barbed Wire Patent*, 143 U.S. 275 (1892), and *Goodyear Tire & Rubber Co. v. Ray-O-Vac Co.*, 321 U.S. 275 (1944). Since the enactment of the nonobviousness requirement for patentability in 1952, decisions of this Court on obviousness include *Graham v. John Deere, Co.*, 383 U.S. 1 (1966); *United States v. Adams*, 383 U.S. 39 (1966); *Anderson's-Black Rock, Inc. v. Pavement Salvage Co.*, 396 U.S. 57 (1969); and *Dann v. Johnston*, 44 U.S.L.W. 4463 (U.S., March 31, 1976).

In the landmark case of *Smith v. Goodyear Dental Vulcanite Co., supra*, the Court held commercial success as a factor to be considered in determining validity of a patent. The patent involved a new method of making dental plates by inserting artificial teeth into a rubber denture. After proper placement of the artificial teeth in the rubber, the rubber was vulcanized to form a hard plate for chewing by the patient, yet flexible enough to yield to the patient's mouth. Because dentures made by the method were a cheap, durable substitute for gold plates, the invention com-

pletely dominated the industry and displaced previous methods of making dental plates. The overwhelming commercial success was sufficient to find patentability, even though each separate individual step was old.

Before reversing a lower court and holding a patent valid, this Court in *The Barbed Wire Patent, supra*, traced the patented device to the market place. The success of the invention was attributed to the improvement made and claimed by the inventor. Even recognizing the inventor may have simply taken a final step, the Court had no reluctance in light of the success to hold the patent valid.

In *Goodyear Tire & Rubber Co. v. Ray-O-Vac Co., supra*, the patent involved a leak-proof dry cell flashlight battery. After pointing out the use of flashlight batteries for half a century, consciousness of the defects by the manufacturers and no method of curing the defects, the Court relied on commercial success to hold the patent valid. The trial court had held the substitution of structure and material to be no more than a choice of mechanical alternatives.

The "nonobviousness" standard for patentability was enacted in 1952 as 35 U.S.C. §103. This Court in *Graham v. John Deere Co., supra*, held the nonobviousness standard of patentability to simply be a codification of already existing case law. The Court further recognized the previous law that "secondary considerations as commercial success, long felt but unsolved needs, failure of others, etc., might be utilized to give light to the circumstances surrounding the

origin of the subject matter sought to be patented". *Id.*, pp. 17-18.

On the same day as the *Graham* decision, in the companion case of *United States v. Adams, supra*, this Court upheld the validity of a patent where all elements of the patent were well known in the prior art. The inventor had gone against known disadvantages of the prior art in the combination of old elements. This disregard of known disadvantages must be taken into account in determining obviousness.

In *Anderson's-Black Rock, Inc. v. Pavement Salvage Co., supra*, when two well-known elements were mounted on a common frame to perform their common function, this Court held the patented combination as invalid. No amount of commercial success could make the combination a valid patent because no invention existed.

In the recent case of *Dann v. Johnston, supra*, the patent was held invalid under 35 U.S.C. § 103 in view of the prior art. No one contended that secondary considerations offered any support on the issue of nonobviousness.

The standard for patentability as set forth in the above authorities apply to the present case. While the individual elements used to practice the present method claim are old, none of the references teach the use of the present combination of steps to control the fuel-air mixture of an airplane in flight. Utility as required under 35 U.S.C. § 101 exists in the claimed method of fuel-air control. Novelty as required by 35

U.S.C. §102 was not considered by the Court of Appeals. The Court of Appeals simply made the final determination of obviousness to hold the patent invalid. After determining what constitutes prior art to be considered in an obviousness test, the secondary considerations as enunciated hereinabove must be taken into account.

While the Court recognized in *Graham v. John Deere Co., supra*, the difficulties in applying the nonobviousness test, the various Courts of Appeals have no consistent standards in applying the "secondary considerations" to the obviousness test. Some Courts of Appeals are even in conflict with themselves when applying the secondary considerations to determine obviousness. A synopsis of the conflicts within the Courts of Appeal since *Graham, supra*, is summarized in the following paragraphs:

First Court of Appeals

The First Circuit recognizes that unsuccessful efforts of others and commercial success do not require a finding of nonobviousness. *Nashua Corp. v. RCA Corp.*, 431 F.2d 220, 166 U.S.P.Q. 449 (1st Cir. 1970). Yet, the First Circuit has required before the acceptance of a summary judgment that the trial court make an "inquiry into the existence of a long felt need, the extent of efforts directed at this need, the relevance of Colourpicture's commercial success, the acceptance of the device by customers — the subtests which, while secondary, might have relevance". *Colourpicture's Publishers, Inc. v. Mike Roberts Color Productions, Inc.*, 394 F.2d 431 at 434, 157 U.S.P.Q. 659 at 661 (1st Cir. 1968), cert. denied, 393 U.S. 848, 159 U.S.P.Q. 799 (1968).

Second Court of Appeals

In the Second Circuit, much less emphasis is placed on the secondary considerations in determining obviousness as can be seen in the representative case of *Timely Products Corp. v. Arron*, 523 F.2d 288, 187 U.S.P.Q. 257 (2nd Cir. 1975). This lower emphasis by the Second Circuit ignores the landmark decision from that circuit by Judge Learned Hand in *Reiner v. I. Leon Co., Inc.*, 285 F.2d 501, 128 U.S.P.Q. 25 (2nd Cir. 1960), which decision was relied upon by the Court in *Graham, supra*. Judge Hand very adequately stated the principle for secondary considerations as follows:

> "We are of course acutely aware of the constant reminders in the books that the sale of a patented device is not alone a measure of its invention, and we accept that conclusion. Nevertheless, great commercial success, when properly scrutinized, may be a telling circumstance. It is idle to say that combination of old elements cannot be inventions; substantially every invention is for such a "combination": that is to say, it consists of former elements in a new assemblage. All the constituents may be old, if their new concourse would not 'have been obvious at the time the invention was made to a person having ordinary skill in the art'. (§103, Title 35).
>
> . . . .
>
> There are indeed some signposts: e.g. how long did the need exist; how many tried to find the way; how long did the surrounding and accessory arts disclose the means; how immediately was the invention recognized as an answer by those who used the new variant?" *Id.*, p. 503.

Third Court of Appeals

The Third Circuit merely cites the principles of secondary considerations without indicating the weight given to the secondary considerations, if any. *Trio Process Corp. v. L. Goldstein's Sons, Inc.*, 461 F.2d 66, 174 U.S.P.Q. 129 (3rd Cir. 1972), cert. denied, 409 U.S. 997, 175 U.S.P.Q. 577 (1972).

Fourth Court of Appeals

The Fourth Circuit normally relies on the old axiom that commercial success without invention does not give patentability. The secondary considerations are simply mentioned in the decision and not applied in determining obviousness. *Blohm & Voss AG v. Prudential-Grace Lines, Inc.*, 489 F.2d 231, 180 U.S.P.Q. 165 (4th Cir. 1973), cert. denied, 419 U.S. 840, 183 U.S.P.Q. 321 (1974).

Fifth Court of Appeals

More emphasis is placed on the secondary considerations by the Fifth Circuit than most other Courts of Appeals. Some of the language used by the Fifth Circuit when applying secondary considerations to determine nonobviousness is as follows:

> (1) "An abundance of evidence of the unsuccessful efforts of many highly skilled

technicians in their attempts to fill the need which the H valve admittedly filled . . . rapid acceptance . . . failure of others to develop it despite the pressing need." *Hobbs v. United States*, 451 F.2d 849 at 864, 171 U.S.P.Q. 713 (5th Cir. 1971).

(2) "A combination of elements may result in an effect greater than the sum of the several effects taken separately. Such a synergistic result is strong evidence if not conclusive evidence of nonobviousness . . . a long felt need . . . in excess of 30 years." *Van Gorp Mfg., Inc. v. Townley Industrial Plastics, Inc.*, 464 F.2d 16 at 20-21, 175 U.S.P.Q. 367 (5th Cir. 1972). (The prior art had been known for many years.)

(3) "A breakthrough in the oil industry's need for an *inexpensive* feeder designed for the *quick, efficient* and thorough mixing of polymers with liquids." (Emphasis added) *Gaddis v. Calgon Corp.*, 506 F.2d 880 at 884, 184 U.S.P.Q. 449 (5th Cir. 1975).

(4) "One skilled in the art would not have searched for a solution in the direction White took . . . . unrebutted and persuasive evidence that his machine was commercially successful in fulfilling a previously unmet need." *White v. Mar-Bel, Inc.*, 509 F.2d 287 at 291, 185 U.S.P.Q. 129 (5th Cir. 1975).

Sixth Court of Appeals

The Sixth Circuit takes a middle-of-the-road approach to secondary considerations in determining nonobviousness. Some cases simply apply the axiom that an invention must be present before the secondary considerations are considered. *Phillips Industries, Inc. v. State Stove & Mfg. Co., Inc.*, 522 F.2d 1137, 186 U.S.P.Q. 458 (6th Cir. 1975). In *Bolkcom v. Carborundum Co.*, 523 F.2d 492, 187 U.S.P.Q. 466 (6th Cir. 1975), the Court held that "utility and novelty of appellants' invention is demonstrated by the undisputed need of the industry". *Id.*, p. 499. Further, the Court stated "the fact that each element of creation sought to be patented is found in prior art does not negate novelty if the old elements are combined in such a way that as a result of the combining an improved, useful, and more advantageous innovation is obtained". *Id.*, p. 500.

Seventh Court of Appeals

While the Seventh Circuit normally cites the secondary considerations as given in *Graham, supra*, it will then simply apply one of its two conflicting lines of decisions to support its judgment, leaving the other line of decisions unexplained. *Chicago Rawhide Mfg. Co. v. Crane Packing Co.*, 523 F.2d 452, 187 U.S.P.Q. 540 (7th Cir. 1975); *E-T Industries, Inc. v. Whittaker Corp.*, 523 F.2d 636, 187 U.S.P.Q. 369 (7th Cir. 1975); *Tracor, Inc. v. Hewlett-Packard Co.*, 519 F.2d 1288, 186 U.S.P.Q. 468 (7th Cir. 1975). A Seventh Circuit case strongly paralleling the present case is *National Dairy Products Corp. v. The Borden Co.*, 394 F.2d 887, 157

U.S.P.Q. 227 (7th Cir. 1968), cert. denied, 393 U.S. 953, 159 U.S.P.Q. 799 (1968). The Court recognized the long felt need and at least four years of work by people skilled and experienced in the art to solve the problem as strong evidence of nonobviousness. Although the individual steps were known, experiments by those skilled in the art led them away from the patented method. These facts are substantially the same as the facts of the present case. Decisions of the Seventh Circuit cannot be reconciled with each other, much less decisions of this Court.

Eighth Court of Appeals

If the Eighth Circuit reaches the question of obviousness, mention is given in the record to secondary considerations. However, the Eighth Circuit almost always holds the patent obvious under the primary considerations of *Graham, supra*, without ever giving weight to the secondary considerations. *Hadfield v. Ryan Equipment Co.*, 456 F.2d 1218, 173 U.S.P.Q. 322 (8th Cir. 1972); *National Connector Corp. v. Malco Mfg. Co.*, 392 F.2d 766, 157 U.S.P.Q. 401 (8th Cir. 1968), cert. denied, 393 U.S. 923, 159 U.S.P.Q. 799 (1968). Patent owners would rather have the validity of their patents determined by any other Court of Appeals than the Eighth Circuit. Because of the judicial attitude of the Eighth Circuit, there are numerous races to the courthouse by the patent owners to select a better forum for determining infringement, which infringement claim normally results in a counterclaim of invalidity.

Ninth Court of Appeals

In the Ninth Circuit from which this Writ was taken, one line of authorities simply bypasses the secondary considerations for determining nonobviousness by holding invention to be lacking, citing the pre-section 103 case of *Great Atlantic & Pacific Tea Co. v. Supermarket Equipment Co.*, 340 U.S. 147, 87 U.S.P.Q. 303 (1950). See *Exer-Genie, Inc. v. McDonald*, 453 F.2d 132, 171 U.S.P.Q. 277 (9th Cir. 1971), cert. denied, 405 U.S. 1075, 173 U.S.P.Q. 385 (1972); *Hewlett-Packard Co. v. Tel-Design, Inc.*, 460 F.2d 625, 174 U.S.P.Q. 140 (9th Cir. 1972). In another line of cases, the Ninth Circuit has determined nonobviousness by applying the secondary considerations. As stated by the Ninth Circuit is *Reeves Instrument Corp. v. Beckman Instruments, Inc.*, 444 F.2d 263, 170 U.S.P.Q. 74 (9th Cir. 1971), cert. denied, 404 U.S. 951, 171 U.S.P.Q. 641 (1971):

> "Our review of the record reveals some fifteen approaches to the problem solved by the McCoy patent. When the evidence shows that several others in the art have attempted to solve the same problem and have not arrived at the solution claimed by the patent in suit, the statutory presumption of validity is substantially strengthened." *Id.*, p. 272.

Again, in *Cool Fin Electronics Corp. v. International Electronic Research Corp.*, 491 F.2d 660, 180 U.S.P.Q. 481 (9th Cir. 1974), the Ninth Circuit stated:

> "[T]he evidence shows that others skilled in the field, notably military researchers, had been unable to find a satisfactory solution to

> the problem of electron tube failures. This is a weighty induction that at the *then* level of skill as to tube covers, the patent discovery was not obvious." *Id.*, pp. 662-663.

Despite the seemingly favorable language quoted hereinabove, the Ninth Circuit has two lines of authorities in total conflict with each other. As a general rule, the Ninth Circuit normally applies the obviousness test against the patent owner, even with secondary considerations.

Tenth Court of Appeals

The secondary considerations are given considerable weight by the Tenth Circuit, even if the patent involved is a combination of old elements. *A. E. Staley Mfg. Co. v. Harvest Brand, Inc.*, 452 F.2d 735, 171 U.S.P.Q. 795 (10th Cir. 1972), cert. denied, 406 U.S. 974, 174 U.S.P.Q. 4 (1972). Simplicity of the invention is not a bar to patentability. In *Maloney-Crawford Tank Corp. v. Sauder Tank Co., Inc.*, 465 F.2d 1356, 175 U.S.P.Q. 141 (10th Cir. 1972), the Tenth Circuit held "a patent that fits a long felt need should have the benefit of any doubt". *Id.*, p. 1366.

Court of Customs and Patent Appeals

The Court of Customs and Patent Appeals takes a very strong approach to the use of secondary considerations in a determination of obviousness. The secondary considerations must *always* be considered. *In re Fielder and Underwood*, 471 F.2d 640, 176 U.S.P.Q. 300 (C.C.P.A., 1973).

Summary

A careful reading of the Opinion of the Court of Appeals (Appendix C) and Findings of Fact and Conclusion of Law by the District Court (Appendix A) reveals the true reason why these courts determined the method claim "lacks invention". This reason is not because anyone practiced the patented method of fuel-air mixture control, but because those skilled in the art *could have* used the principles of the invention and *could have* practiced the patented method of Hundere's invention. This begs the question. All of the principles, as well as the long felt need, were known for many years. MOST IMPORTANTLY, all the witnesses who claimed they *could have* practiced the Hundere invention did not even understand the claimed invention. When asked under cross-examination to explain in their own words how they would practice Hundere's invention, each witness explained the prior art method of plotting a curve of EGT versus fuel flow.

Why was the patented method not practiced if it was obvious? Many previous attempts by highly skilled individuals in the field were made to solve the problem. The closer references taught away from Hundere's invention. Upon introducing Hundere's invention to a very sophisticated class of customers with a minimum of advertising, it was immediately accepted by the industry. Those knowledgeable in the field had considerable praise for Hundere's invention. Most importantly, the patented invention was an instantaneous commercial success throughout the country.

A good reference discussing commercial success and its application in a determination of patent validity is contained in Boyer, *Commcercial Success as Evidence of Patentability,* 37 Fordham L. Rev. 573 (1969). As suggested in the scholarly article by Professor Boyer, the judiciary should review in detail the backgrouna of the commercial success to determine if the success is attributable to the invention, or due to other factors, such as extensive advertising.

CONCLUSION

Petitioner submits that its Writ of Certiorari should be granted to resolve the conflict between the lower courts when applying secondary considerations in a determination of obviousness of a patent. The secondary considerations established by Petitioner, and essentially unrebutted by Respondent, are as follows:

1. A long felt need existed in the industry for a good fuel-air mixture control for piston engine aircraft.
2. Many previous attempts were made by many highly skilled individuals in the field to solve the fuel-air mixture problem.
3. The prior art taught away from the patented invention.
4. The patented invention was immediately accepted by the industry despite minimum advertising in a sophisticated market.
5. Those knowledgeable in the industry had considerable praise for the patented invention as a major development.

6. The patented invention enjoyed instantaneous commercial success throughout the industry and is now the accepted method of fuel-air mixture control for piston engine aircraft.

Petitioner submits the above given secondary considerations should be considered in any determination of obviousness. Because of the conflicts in the lower courts when applying secondary considerations in a determination of obviousness, the Supreme Court should grant Petitioner's Writ of Certiorari to resolve the conflict, and place this case on its calendar for oral argument.

Respectfully submitted,

Ted D. Lee

Edward B. Gregg

ATTORNEYS FOR PETITIONER

CERTIFICATE OF SERVICE

I, Ted D. Lee, do hereby certify that true and correct copies of the foregoing Petition for a Writ of Certiorari to the United States Court of Appeals for the Ninth Circuit have been mailed to Benjamin F. Berry, of Seed, Berry, Vernon & Baynham, 1001 Bank of California Center, Seattle, Washington 98162, counsel for Respondent herein, on this the ___ day of April, 1976.

Ted D. Lee

APPENDIX A

United States District Court
Western District of Washington
at Seattle

ALCOR AVIATION, INC.
a Corporation,
Plaintiff,
versus

RADAIR INCORPORATED, a Corporation,
Successors to RADAIR, INC. and UNIWEST, INC.
Defendants.

C.A. No. 8997

FINDINGS OF FACT AND CONCLUSIONS OF LAW

This action was tried by the Court without a jury and the Court hereby finds the facts, states its conclusions of law, and directs entry of an appropriate judgment, as follows:

FINDINGS OF FACT

1. Plaintiff, Alcor Aviation, Inc., is a Texas corporation having its principal place of business in San Antonio, Texas. (PTO-2)*

2. Defendant, Radair, Incorporated, is a Washington corporation having its principal place of business in Seattle, Washington. Radair, Incorporated

* References herein are as follows:
P-Plaintiff's exhibit — PTO-Pretrial Order Agreed Fact
D-Defendant's exhibit — Tr-Transcript

is a successor in business of Radair, Inc. and Uniwest, Inc. (PTO-3)

3. United States Letters Patent Number 3,154,060 was issued on October 27, 1964 on an application filed November 5, 1962, entitled, "Reciprocating Piston Gasoline Engine Fuel-Air Ratio Control". The plaintiff owns the patent by reason of an assignment from the inventor, Alf Hundere, executed May 21, 1970. (PTO-4)

4. Admitted Facts 5 through 16 inclusive are included and made a part hereof by reference as constituting Findings of Fact herein.

5. Plaintiff and defendant are direct competitors in the business of manufacturing and selling exhaust gas temperature (EGT) systems covered by the claims of the Hundere patent in suit.

6. Plaintiff admits the prior art consists of: (a) all of the equipment needed (although improved upon by plaintiff) including probes, meters, and wiring; (b) knowledge that by assembling these with the probe in the exhaust of a reciprocating piston gasoline engine, the meter will read EGT; (c) knowledge that EGT varies with fuel-air ratio and peaks at the stiochoimetric ratio (PLAINTIFF'S POST-TRIAL BRIEF, page 16, lines 14-20).

7. Plaintiff charged defendant with infringement of claims 1-6 of the Hundere, United States Patent Number 3,154,060.

8. Defendant affirmatively asserted that all claims of Hundere, United States Patent Number 3,-150,060 are invalid and, therefore, cannot be infringed and sought a ruling of invalidity of apparatus claims 1 and 2 as well as method claims 3 to 6, inclusive. Additionally, defendant asked for costs, a holding that the case is an "exceptional case", and attorney's fees under 35 U.S.C. §285.

9. Douglas Moreton and Richard Jahnke, as well as the patentee, himself, Alf Hundere, were persons of ordinary skill in the art to which the alleged invention pertains at the time the invention was made, and Moreton, Jahnke and Hundere, at various times prior to the time the invention was made, used the apparatus recited in the claims of the Hundere patent on test stand procedures to vary the fuel-air ratio and noted variations in the EGT through a wide range of temperatures, from rich to lean, including peak EGT, for the purpose of gathering data on internal combustion gasoline engine performance.

10. Robert E. Johnson, Charles R. Mercer, and Dr. Walter L. Howland were persons of ordinary skill in the art to which the alleged invention pertains at the time the invention was made, and Johnson, Mercer and Howland, at various times prior to the time the invention was made, used the apparatus and method steps recited in the claims of the Hundere patent during in-flight tests of aircraft internal combustion gasoline engines for the purpose of gathering data on such engines.

11. Richard Jahnke possessed the knowledge and skill required to have used EGT to control the fuel-air ratio of the internal combustion gasoline engine of an aircraft in-flight as a result of his experience involving test stand procedures on the Curtiss R3350 engine prior to the time the alleged invention claimed in the Hundere patent in suit was made.

12. Richard Jahnke, in his activities as an instructor with aircraft pilots, using the Curtiss-Wright Manual, (D-30), prior to the time the alleged invention claimed in the Hundere patent was made, gave such aircraft pilots enough training so that (if they had had the prior instrumentation) the aircraft pilots could have used EGT to control fuel mixture during aircraft flight.

13. The Brake Mean Effective Pressure (BMEP) method of mixture control was used as the operational method of control in the Curtiss-Wright engines since it was considered more desirable to have the direct power reading afforded by BMEP rather than to rely on the indication of exhaust gas temperature (EGT) because of a need to know power requirements for engine protection.

14. All of the elements recited in claims 1 and 2 of the Hundere patent in suit were old and well-known in the prior art at the time the invention was made and function together in the expected manner, as taught by the prior art, to produce the expected result.

15. All of the method steps recited in claims 3 to 6, inclusive, of the Hundere patent in suit were old in the

prior art at the time the invention was made and, when performed in the manner recited, produce the expected result taught by the prior art.

16. The scope and content of the prior art, the differences between the prior art and the claims of the patent in suit, and the level of ordinary skill in the pertinent art were such that, at the time Hundere made the invention which was the basis for the patent in suit, there was nothing unobvious about the invention to a person having ordinary skill in the art of internal combustion engine thermodynamics to which the alleged invention pertains; there were no "new and unexpected" or "unusual or surprising" results and, therefore, the alleged invention did not meet the requirements of 35 U.S.C. §103.

17. Secondary factors of commercial success, long-felt need, solution to a prior art problem, failure of others, etc., have been taken into consideration but are not a substitute for patentable invention and are not sufficient to uphold validity of the Hundere patent in suit because the invention as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which the subject matter of the Hundere patent pertains.

18. The Minter United States Patent Number 1,251,-751, (D-5), discloses the basic relationship between fuel-air ratio and EGT, col. 1, lines 22-27, and teaches a method of using this relationship for automatically controlling fuel mixture by the use of temperature sensing means in the exhaust gas stream.

19. The Pratt-Whitney Handbook, (D-7), and the Curtiss-Wright Manual, (D-30), clearly teach the basic relationship between fuel-air ratio and exhaust gas temperature, including peak EGT, and recognize that it can be used to control the fuel mixture.

20. Flight tests conducted on the Lockheed Constellation series and Douglas DC-7 in th 1950's and the inventor, Mr. Alf Hundere's own tests utilizing EGT probes and temperature gauges in internal combustion engines as early as 1941 utilized the basic relationship between fuel-air ratio and exhaust gas temperature (EGT), including peak EGT, and illustrated that EGT could be used to control the fuel-air mixture.

21. The Weston advertising brochure, (D-8), the Kates United States Patent Number 1,653,213, (D-3), the Smith United States Patent Number 2,445,156, (D-6), the instrumentation used in the Lockheed Constellation and Douglas DC-7, (in the early 1950's) and the apparatus used in the tests conducted in 1941 by the patentee, Alf Hundere, all constitute clear anticipatory disclosures of apparatus which include each and every element recited in claims 1 and 2 of the Hundere United States Patent Number 3,154,060.

22. Plaintiff acknowledged that the apparatus claimed in the patent in suit was a part of the prior art at the time he made his invention (PLAINTIFF'S POST-TRIAL BRIEF, page 16, lines 14-20).

23. Method Claims 3 to 5, inclusive, of the Hundere patent in suit are not limited to any specific reciprocating piston gasoline engine but Claim 6 of the patent is

limited specifically to a reciprocating piston gasoline airplane engine of an airplane in flight. All of these claims require operating the engine under constant conditions and while so operating, adjusting the fuel-air ratio, noting when the peak EGT has been reached and then adjusting the fuel-air ratio in relation to the observed peak. Claim 6, the narrowest of the method claims, calls for the following sequence of steps: (1) operating an airplane powered by a reciprocating piston gasoline engine in flight under constant conditions; (2) while the engine and aircraft are so operating, manually operating the fuel-air ratio adjustment means to vary the fuel-air ratio; (3) while so doing, visually observing the EGT temperature indicator until a maximum EGT is noted; (4) and then manually setting the fuel-air ratio adjustment means to produce an EGT having a pre-determine relation to the observed maximum EGT.

24. The method recited in claims 3 to 6, inclusive, is for "controlling the fuel-air ratio of a reciprocating piston gasoline engine". The claims are not restricted to "control" for any specific purpose. Hence, the "control" may be for test purposes, such as plotting, curves, gathering data, or simply determining the characteristics of any given engine, in-flight control for maximum power or economy, to protect auxiliary equipment in the exhaust gas stream, e.g., valves and turbines, to monitor various aspects of performance, such as prop feathering, engine loading, etc. As long as the three basic steps enumerated in Finding of Fact Number 23 are carried out, the claimed method had been practiced.

25. The procedures used to gather the data and plot the EGT/fuel-air ratio curve, such as shown on the graph of Fig. 10 of the Pratt-Whitney Installation Handbook, (D-7) constitute the practice of the method recited in claims 3 to 5, inclusive, of the Hundere patent in suit.

26. The test stand procedures performed in 1941 by the patentee, Alf Hundere, using EGT test equipment, the test stand procedures used by Richard Jahnke on the Curtiss-Wright R3360 turbo compound engine, and the test stand procedures used by Douglas Moreton at Standard Oil and Douglas Aircraft occurred before the patented invention was made and embodied each step of the method recited in claims 3 to 5, inclusive, of the Hundere patent in suit.

27. The steps performed by Robert E. Johnson, Charles R. Mercer, and Dr. Walter L. Howland during in-flight tests using EGT test equipment in the Lockheed Constellation aircraft in the early 1950's embodied the practice of each step of the method recited in claims 3 to 6, inclusive, of the Hundere patent in suit.

28. The alleged invention which was the basis for the Hundere patent in suit was known and used by others in this country and described in printed publications long before the invention thereof by the patentee, Alf Hundere, and, therefore, fails to meet the requirements for patentability of 35 U.S.C. 102(a).

29. The invention which was the basis for the Hundere patent in suit was described in printed

publications and was in public use in this country more than one year prior to the date of filing of the application which matured into the Hundere United States Patent Number 3,154,060, and, therefore, fails to meet the requirements for patentability of 35 U.S.C. 102(b).

30. None of the prior art patents cited by the Examiner and considered during the prosecution of the Hundere patent recognizes or discusses the relationship between fuel-air ratio and exhaust gas temperature (EGT), including peak EGT, or the fact that it (EGT) could be used as an indicator to control the fuel mixture.

31. In 1941, while Alf Hundere, the patentee, was making tests at the Standard Oil Company, he publicly used the exhaust gas temperature (EGT) test equipment described in Claims 1 and 2 of the patent in suit (constituting a probe or sensor inserted in the exhaust system, indicator means for indicating the sense temperature and wiring to connect the probe to the indicator).

32. Alf Hundere, the patentee, knew that the Lockheed and Douglas flight tests were being conducted in the early 1950's with what he, himself, described at trial as "standard" EGT test equipment (2 Tr. 210, 211) involving internal combustion gasoline aircraft engines and was aware of this public use when he applied for the patent in suit more than ten years (10) later, on November 5, 1962.

33. Alf Hundere, the patentee, testified at the trial that he knew that the relationship between fuel-air ratio and EGT had been known for many years, as early as the 1930's, and had been disclosed in publications and was aware of this prior public knowledge when he applied for the patent in suit on November 5, 1962.

CONCLUSIONS OF LAW

1. The Court has jurisdiction of the parties and of the subject matter of this law suit.

2. All claims of Hundere United States Patent 3,-154,060 are invalid for failure to meet the requirements of 35 U.S.C. §103 because the claimed invention, both apparatus and method, was obvious at the time the invention was made to a person having ordinary skill in the art to which the subject matter of the invention pertains.

3. All claims of Hundere United States Patent Number 3,154,050 are invalid for failure to meet the requirements of 35 U.S.C. 102(a) because the claimed invention, both apparatus and method, which was the basis for the patent was directly anticipated by the prior art since it was known and used by others in this country and described printed publications long before the invention thereof by the patentee.

4. All claims of Hundere United States Patent Number 3,154,060 are invalid for failure to meet the requirments of 35 U.S.C. 102(b) because the claimed invention, both apparatus and method, which was the basis for the patent was directly anticipated by the

prior art since it was described in printed publications and was in public use in this country more than one year prior to the date of the application for the Hundere patent.

5. The complaint must be dismissed and defendant is entitled to a judgment in accordance with the foregoing and each party must bear his own attorney fees and costs.

6. Any conclusion of law entered herein which may properly be construed in whole or in part as a finding of fact shall be so deemed and treated as if set forth under Findings of Fact.

Dated this 31st day of July, 1972.

/s/ WALTER T. McGOVERN
WALTER T. McGOVERN
United States District Judge

APPENDIX B

United States District Court
Western District of Washington
At Seattle

ALCOR AVIATION, INC.
a Corporation,
Plaintiff,

versus

RADAIR INCORPORATED, a Corporation,
Successors to RADAIR, INC. and UNIWEST, INC.
Defendants.

C.A. No. 8997

JUDGMENT

The Court having heretofore made and entered into its Findings of Fact and Conclusions of Law, and in conformity with said Findings and Conclusions, judgment is entered in favor of the defendant, Radair, Incorporated.

IT IS FURTHER ORDERED, ADJUDGED AND DECREED that United States Letters Patent Number 3,154,060, issued on October 27, 1964 to A. Hundere is invalid in toto, and that the complaint herein is dismissed with prejudice.

Dated this 31st day of July, 1972.

/s/ WALTER T. McGOVERN
WALTER T. McGOVERN
United States District Judge

APPENDIX C

United States Court of Appeals
for the Ninth Circuit

ALCOR AVIATION, INC.,
Plaintiff-Appellant,

versus

RADAIR INCORPORATED, a corporation, Successor to RADAIR, INC., and UNIWEST, INC.,
Defendant-Appellee.

Cause No. 72-2708

Appeal from the United States District Court for the Western District of Washington, at Seattle

Before: WRIGHT and WALLACE, Circuit Judges, and LYDICK,* District Judge

WALLACE, Circuit Judge:

Alcor Aviation, Inc. (Alcor) is the assignee of Patent No. 3,154,060, filed in 1962 and granted in 1964, which relates to an apparatus and method for manually setting the fuel-air mixture of internal combustion gasoline engines by reference to exhaust gas temperature. Alcor sued Radair Incorporated (Radair) for infringement and infringement was admitted if the patent was valid. The district court held all six claims under the patent invalid for obviousness, 35 U.S.C. § 103, and lack of novelty, 35 U.S.C. § 102(a), (b). Alcor

* Honorable Lawrence T. Lydick, United States District Judge, Central District of California, sitting by designation.

appeals only the ruling on the validity of claim 6, which relates to a method of controlling the fuel-air mixture of an engine on a flying aircraft.[1] Alcor has disclaimed apparatus claims 1 and 2, as well as method claims 3, 4 and 5. We affirm the district court's holding that claim 6 lacked inventiveness because it would have been obvious to one having ordinary skill

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1 Claim 4 is a method of mixture control and claim 6 is that method as utilized in an airplane in flight. Combined with claim 4, claim 6 reads:

> The method of controlling the fuel-air ratio of a reciprocating-piston gasoline engine [of an airplane in flight] having, for the fuel mixture supplied thereto, a fuel-air ratio control system with manually operable means for adjustment of such ratio between a ratio leaner than and a ratio richer than the stoichiometric ratio, such engine upon operation under constant conditions being characterized by having a maximum exhaust gas temperature that is obtainable by manual adjustment of said manually operable means, and having an exhaust gas temperature sensing and visually indicating means capable of sensing and visually indicating such exhaust temperature during changes thereof resulting from manual adjustment of said manually operable means, the time lag of temperature sensing and indication behind temperature change being so small that indication substantially follows change, which method comprises: operating such an engine under constant conditions, while such engine is so operating, manually operating said means for adjustment of such ratio to vary such ratio and visually observing said indicating means while so varying such ratio so as to correlate such manual operation with such observations to effect indications of temperature rise and fall as the ratio is varied either from rich to lean or from lean to rich, such observations including determination of the maximum temperature indication, and then manually setting said means for adjustment to give a visual indication of an exhaust temperature having a predetermined relationship to such maximum temperature indication.

in the pertinent art.[2] Thus we need not consider other grounds also used by the district court upon which the patent was found to be invalid.

Gasoline piston engines ignite a mixture of air and gasoline for combustion and proper performance depends upon a correct ratio of gas to air. Because the conditions of combustion vary as an aircraft increases or decreases speed and altitude, the proper mixture setting changes during flight. Although some general aviation planes have automatic devices which control mixture, most have a control by which pilots can manually readjust the mixture setting when a plane changes altitude or speed. Methods to determine the proper mixture control setting include: leaning to roughness, leaning to maximum power (as measured by rpm), leaning by reference to a fuel flow indicator, leaning by reference to the color of the exhaust flame, leaning by reference to a device which analyzes the exhaust gases and leaning by reference to the torque of the engine shaft measured by the brake mean effective pressure. Alcor's patented method of setting the fuel mixture is by reference to the engine exhaust gas temperature (EGT). The method was marketed in conjunction with unpatentable EGT measuring devices and the package was a great commercial success. It is now the most popular mixture control method for general aviation aircraft.

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2 35 U.S.C. § 103 reads in part:

> A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains.

The scientific basis of Alcor's method is that an engine runs hottest when the ratio of fuel to air is such that all of the mixture is burned, leaving no excess of air or fuel. This occurs at a fuel-air ratio of .067, called the "stoichiometric ratio." A rich mixture, more fuel to air than in the stiochiometric ratio, will give greater power; and a slightly lean mixture, less fuel to air than in the stoichiometric ratio, will give greater economy. Either a rich or lean mixture will cause the engine to run cooler, which minimizes mechanical problems associated with hot engines. The EGT of the engine can be measured by a probe in the exhaust which the pilot reads on a meter in the cockpit. The patented method of mixture control is quite simple: as a plane flies at a constant speed and altitude, the pilot merely varies the manual mixture control until the maximum EGT is reached; the mixture is then either leaned or enriched to produce an EGT having a predetermined relation to peak EGT.

The first question is whether the district court properly rejected the statutory presumption of validity of the patent. 35 U.S.C. § 282. A presumption of non-obviousness dissipates upon a showing that the prior art was not brought to the attention of the patent examiner. *Hewlett-Packard Co. v. Tel-Design, Inc.*, 460 F.2d 625, 628 (9th Cir. 1972); *Jacuzzi Bros. v. Berkeley Pump Co.*, 191 F.2d 632, 634 (9th Cir. 1951). The district court made findings as to what the prior art included. Those findings are not clearly erroneous. None of the cited examples of prior art was considered by the examiner. For instance, the 1941 Minter patent, No. 1,-251,751, is a device for controlling the fuel-air mixture in airplanes. The district court found that the Minter patent not only discloses the basic relationship between fuel-air ratio and engine exhaust gas

temperature, it also teaches a method of using this relationship for automatically controlling fuel mixture by use of a temperature probe in the exhaust gas stream.

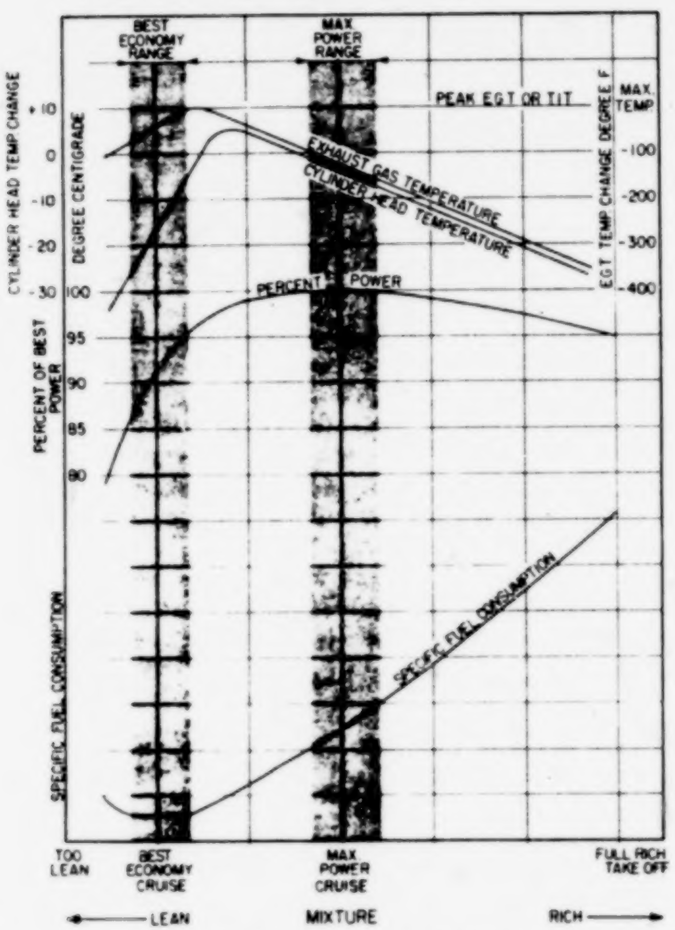
Absent the presumption, the next question is whether the district court erred in determining obviousness. Whether the subject matter of a patent was obvious is decided by considering the scope and content of the prior art, the differences between the prior art and the disputed claim, and the level of ordinary skill in the pertinent art. *Graham v. John Deere Co.*, 383 U.S. 1, 17 (1966); *Walker v. General Motors Corp.*, 362 F.2d 56, 59 (9th Cir. 1966). The district court correctly determined that the art of internal combustion engine thermodynamics was the art pertinent to Alcor's patent. Alcor admits that the probes and meters were used in the prior art to measure EGT. It was also textbook knowledge that EGT varies with the fuel-air ratio and peaks at the stoichiometric ratio. In addition, it was known that best power or best economy is achieved by a mixture setting either richer or leaner than the stoichiometric ratio, as represented by peak EGT. Although Alcor's patent does not mention specific relationships, even the exact EGT drop for many engines was known in the prior art, readily available in pilot manuals and test studies.

Moreover, these EGT devices and theories were utilized together in the prior art. EGT probes and indicators were used in testing new airplane engines, both on the ground and in the air. Examples discussed during the trial included the Curtiss-Wright test stand practices in the 1940's and the Lockheed Constellation and Douglas DC-7 in-flight tests in the early 1950's. Under constant conditions, the fuel-air mixture was varied and all changes in engine performance noted,

including such variables as cylinder head temperature, power (as measured by brake mean effective pressure), fuel consumption and, of course, exhaust gas temperature. Indeed, it was from these tests that graphs such as Diagram I were composed showing the relationships between fuel-air ratio and other variables. These graphs, with discussion of the various relationships, were published in professional journals and utilized in manuals for pilot training such as the Curtiss-Wright manual, *Basic Theory of Operation, Turbo Compound Engine* (1957).

DIAGRAM I

REPRESENTATIVE EFFECT OF LEANING ON CYLINDER HEAD TEMPERATURE, EGT (EXHAUST GAS TEMPERATURE) ENGINE POWER AND SPECIFIC FUEL CONSUMPTION AT CONSTANT ENGINE RPM AND MANIFOLD PRESSURE



FUEL-AIR RATIO

Any of the dependent variables such as illustrated in Diagram I could be used to set the fuel-air mixture. For example, cylinder head temperature, measured by a probe in the cylinder head, and read on a meter in the cockpit, was used as a rough means of mixture control; however, it was unsuitable because of the time lag between mixture adjustment and change in cylinder head temperature. The graph also shows that the mixture could be adjusted by reference to the power of the engine, which was measured by a device indicating brake mean effective pressure. This method was quite feasible; indeed it was the primary system of mixture control in large aircraft such as the Lockheed Constellation and Douglas DC-7.

Alcor argues that its patent was the first to recognize the theory of fuel-air mixture control by reference to the EGT. The district court found to the contrary and that finding is not clearly erroneous. Knowledge in the prior art as reflected in Diagram I, by itself, adequately supports the judge's finding. The district court found it a well-known theory in the prior art that fuel-air mixture could be set by reference to any of the variables charted in Diagram I. The court also found that the Pratt-Whitney handbook, *The Aircraft Engine and its Operation* (1946) and the Curtiss-Wright manual "clearly teach the basic relationship between fuel-air ratio and exhaust gas temperature, including peak EGT, and recognize that it can be used to control the fuel mixture." Further, the court determined that "[f]light tests conducted on the Lockheed Constellation series and Douglas DC-7 in the 1950's and the inventor['s]. . . own tests utilizing EGT probes and temperature gauges in internal combustion

engines as early as 1941 utilized the basic relationships between fuel-air ratio and exhaust gas temperature (EGT), including peak EGT, and illustrated that EGT could be used to control the fuel-air mixture."[3]

Beyond bare theory, the practical method of using one of the dependent variables associated with fuel-air mixture to set mixture was well known in the prior art. The mixture control would be adjusted to give a peak parameter reading; the mixture then would be enriched or leaned to achieve a reading having some predetermined relationship to the peak reading. The predetermined relationship is found by reference to a performance graph for the engine such as illustrated in Diagram I. For example, to set an economy mixture according to brake mean effective pressure, the prior art would lean the mixture to peak power and then lean an additional 10% ("10% drop"). Alcor's patented method is simply this same technique using EGT as the reference variable. Thus a witness found to be representative of those skilled in the prior art, Richard Jahnke, testified that Alcor's claimed method would have been obvious. The district court found that Jahnke, in his activities as pilot instructor in the 1940's, gave pilots training sufficient to enable them, with proper instrumentation, to use EGT rather than brake mean effective pressure to set fuel mixture.

3 The district court noted that the brake mean effective pressure rather than EGT was used as the reference variable in aircraft such as the Lockheed Constellation because pilots needed a direct power reading for the large turbo-compound engines. (Too much horsepower would have caused engine collapse.) The evidence also indicated that, at that time, EGT probes were short-lived.

Considering Alcor's claim against the factual findings of the prior art, the district judge did not err in concluding that there was nothing unobvious about the invention to a person having ordinary skill in the art of internal combustion engine thermodynamics. Alcor's claim is thus no more than a new use for an old device. 35 U.S.C. § 100(b); *see generally*, 2 A. Deller, *Walker on Patents*, § 124, at 294-99 (2d ed. 1964). There is substantial evidence in the record to support the findings that the theory that EGT could be used to set mixture in a flying aircraft was well known in the art and that the actual method of adopting theory to device was not in the last unusual or surprising. *Cf. Regimbal v. Scymansky*, 444 F.2d 333, 338-40 (9th Cir. 1971). The method was a mechanical application of the methodology of mixture control by reference to a dependent variable. *See Pevely Dairy Co. v. Borden Printing Co.*, 123 F.2d 17, 19 (9th Cir. 1941).

Finally, Alcor asserts that the district court erred in not considering such secondary factors as commercial success and recognized need. The district judge, however, adequately discussed these factors and specifically stated that he took them into consideration. Moreover, we note that such secondary considerations cannot make patentable a method which lacks inventiveness. *Hewlett-Packard Co. v. Tel-Design, Inc., supra*, 460 F.2d at 630; *Exer-Genie, Inc. v. McDonald*, 453 F.2d 132, 136 (9th Cir. 1971), *cert. denied*, 405 U.S. 1075 (1972).

AFFIRMED.

APPENDIX D

United States Court of Appeals
for the Ninth Circuit

ALCOR AVIATION, INC.,
Plaintiff-Appellant,

versus

RADAIR INCORPORATED, a corporation, Successor to RADAIR, INC., and UNIWEST, INC.,
Defendant-Appellee.

Cause No. 72-2708

AMENDMENT OF OPINION AND DENIAL OF REHEARING

Before: WRIGHT AND WALLACE, Circuit Judges, and LYDICK,* District Judge

The Opinion filed in the above matter on September 10, 1975, is amended by deletion of the first three sentences of the first full paragraph on page 6 of the slip opinion, which begin with the word "Alcor" and end with the word "finding."

The panel as constituted above has voted to deny the petition for rehearing; Judges Wright and Wallace voted to reject the suggestion for rehearing en banc and Judge Lydick recommended rejection of the same.

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* Honorable Lawrence T. Lydick, United States District Judge, Central District of California, sitting by designation.

The full court has been advised of the suggestion for rehearing en banc and no judge of the court has requested a vote on the suggestion for rehearing en banc. Fed. R. App. P. 35(b).

The petition for rehearing is denied and the suggestion for rehearing en banc is rejected.

APPENDIX E

Oct. 27, 1964 A. HUNDERE 3,154,060
RECIPROCATING-PISTON GASOLINE ENGINE FUEL-AIR RATIO CONTROL
Filed Nov. 5, 1962 2 Sheets-Sheet 1

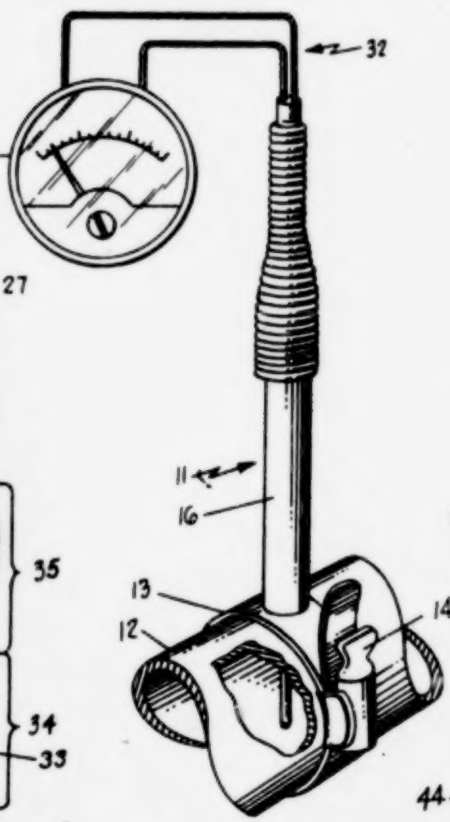

Fig. 1

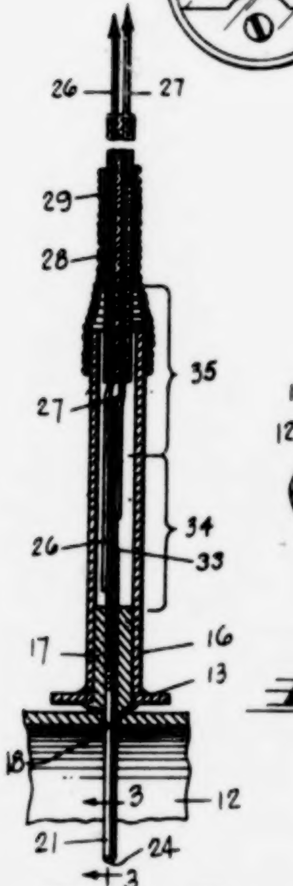

Fig. 2

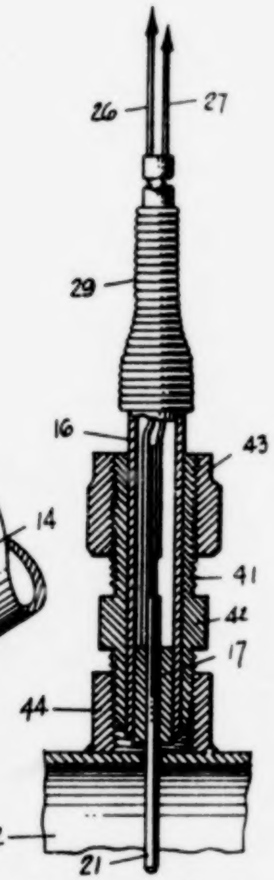

Fig. 4

INVENTOR
ALF HUNDERE
BY Paul Bliven
ATTORNEY

Oct. 27, 1964 A. HUNDERE 3,154,060
RECIPROCATING-PISTON GASOLINE ENGINE FUEL-AIR RATIO CONTROL
Filed Nov. 5, 1962 2 Sheets-Sheet 2

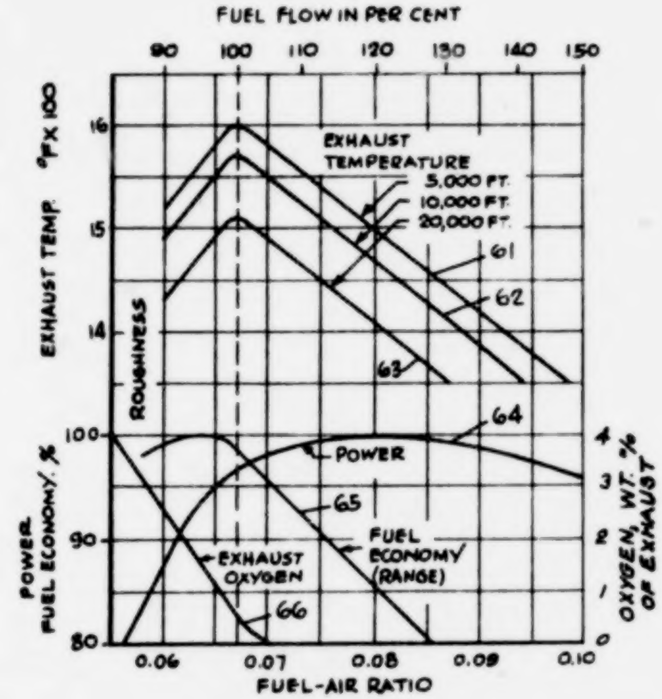

Fig. 6.

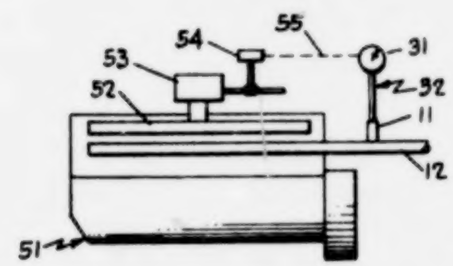

Fig. 5.

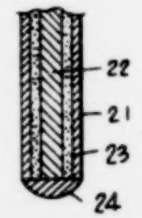

Fig. 3.

INVENTOR
ALF HUNDERE
BY Paul Bliven
ATTORNEY

United States Patent Office

3,154,060
Patented Oct. 27, 1964

3,154,060

RECIPROCATING-PISTON GASOLINE ENGINE FUEL-AIR RATIO CONTROL

Alf Hundere, 2905 Bandera Road, San Antonio, Tex.
Filed Nov. 5, 1962, Ser. No. 235,430
6 Claims. (Cl. 123—119)

The present invention relates to the control of the fuel-air ratio of reciprocating piston gasoline engines. In more particular, the invention relates to a combination of such an engine, its fuel-air ratio adjustment means, and an exhaust gas temperature sensor and indicator for sensing and indicating the temperature of such engine's exhaust gas under operating conditions so that the operator can control the fuel-air ratio in accordance with such indications. Further, the present invention relates to the construction of such sensing and indicating means having such a sensitivity and speed of response that the operator can adjust the fuel-air ratio in a sufficiently short time as needed for improved operation of the engine.

Also, the invention relates to a new method of adjusting the fuel-air ratio of reciprocating piston gasoline engines in accordance with sensitive and rapid indications of the exhaust gas temperature of the engine, and more particularly relates to such a method in which the fuel-air ratio is adjusted in accordance with an indication of the maximum exhaust temperature obtainable by an adjustment of the fuel-air ratio.

In the operation of airplanes not equipped with altitude compensated carburetors, which constitute the vast majority of airplanes in the general aviation category, the fuel-air ratio is controlled in the same manner as on the Model T Ford, that is, manually as a result of the feel and sound of engine operation for the indication of the best mixture of fuel and air. This wastes fuel which on the average, amounts to at least 10% of the fuel used, and, in some cases, it is considerably more. Safety is jeopardized because a mixture that is too lean can cause engine failure from burned valves, and, because, when the mixture is set too rich, as is a common occurrence for a pilot who does not have the proper mixture setting feel, unscheduled landings and crashes can result from the fuel consumption exceeding that anticipated. It has always been recognized that a mixture indicator is needed to eliminate guessing. Exhaust gas analyzers such as the Cambridge analyzer have been available for twenty years or more. These analyzers require a sensing element that responds to change in exhaust gas composition, but these elements are prone to being poisoned by lead from the fuel and other contaminants. The result is that reliability is poor and the maintenance is extremely high. In addition, they have slow response and a very high initial cost. The need for changing settings of the fuel-air adjustment means, in addition to an initial setting, derives from the varying conditions under which an airplane is operated and the need for an optimum fuel-air ratio under each such condition, which ratio is different for each such condition. Such varying conditions are those of power demand and changes in temperature and pressure due either to daily variations or change in altitude.

The present invention particularly further relates to a thermoelectric junction, particularly a hot or temperature sensing junction of a thermocouple having a high sensitivity because of its low thermal inertia and high rate of change in electromotive force (E.M.F.) with change in temperature, together with high resistance to corrosion at elevated temperatures, particularly at the exhaust temperatures of reciprocating piston gasoline engines, such as the range of 1400° F. to 1700° F. An important purpose of the present invention is the development of a thermoelectric temperature sensing junction, a thermo-

couple probe, that can be used to sense the exhaust temperature changes of reciprocating piston gasoline engines as an aid in fuel-air ratio adjustment for needed engine operation. Such a use requires a fast response to temperature changes, that is, the hot junction probe of the thermocouple must have low thermal inertia. In addition, it must have high output per unit temperature change, millivolts per ° F., in order to obtain high sensitivity. Of available thermocouple materials, Chromel-constantan gives the maximum output per unit temperature change, 45 millivolts per ° F. as compared to 23 millivolts per ° F. for Chromel-Alumel, the conventional thermocouple material for exhaust gas temperature measurement. Constantan, however, can not be exposed to exhaust temperatures without excessive corrosive oxidation. If the Chromel-constantan thermocouple is encased in a protective sheath, such as stainless steel, the mass is increased to thereby increase the thermal inertia. If the constantan is located in a sheath, air must be excluded from entering inside the sheath because at exhaust temperatures the constantan readily oxidizes.

Accordingly, an object of the present invention is the devising of a fuel-air ratio control system for reciprocating piston gasoline engines including an exhaust gas temperature sensor and indicator with negligible lag so that optimum ratios may be obtained and maintained with such speed and sensitivity as to enable improved operation of the engine.

More specifically, it is an object to make a Chromel-constantan thermocouple which will have small mass, hence, low thermal inertia, and high resistance to corrosion.

Also, it is an object of the invention to devise a thermocouple in which a constantan metal portion of the hot juncion is protected against corrosion by a Chromel portion of the thermocouple.

It is a further object to devise a thermocouple in which the least corrosive of the two metallic elements of a thermocouple is used to protect the other from contact with a corrosive environment.

Another object of the invention is to devise a thermocouple that has low thermal inertia, high change in E.M.F. per unit temperature change, and resistance to corrosion.

In accordance with a preferred embodiment of the invention, the above-mentioned defects of the prior art fuel-air ratio control systems and thermocouples are remedied and the above objects achieved by the construction of a thermocouple's electrodes in which a Chromel part, or electrode, surrounds and seals a constantan part, or elecrode, against corrosion by the use of a constantan wire coaxial of a Chromel sleeve and with wire and sleeve electrically insulated from each other by a refractory material such as magnesia. The contact, the hot junction, the actual Chromel-constantan junction, is formed at the adjacent free ends of the electrodes by fusion thereof by the use of a helium shielded arc using a Chromel electrode or other metal having sufficient corrosion resistance. This insulation is compacted by swaging or drawing the sleeve, and the inboard end of the sleeve is sealed to the core by means of a high temperature sealant. Leads to a meter circuit are joined to the electrodes at their inboard ends. The hot junction and the adjacent lengths of the electrodes constitute a probe which may be inserted in a medium for temperature determinations, when such junction and electrodes are connected in a proper meter circuit.

Embodiments of the device described briefly above are hereinafter described in detail and illustrated in the accompanying drawings, in which:

FIGURE 1 is a perspective view of one form of the

invention as applied to a section of an engine exhaust pipe with parts of the pipe cut away.

FIGURE 2 is a longitudinal sectional view of FIGURE 1.

FIGURE 3 is an enlarged longitudinal sectional view of the hot junction of either FIGURE 2 or 4 but shown as taken on the line 3—3 of FIGURE 2.

FIGURE 4 is a longitudinal sectional view of a modification of the invention.

FIGURE 5 is a diagramatic showing of the disclosed fuel-air ratio control system applied to an engine.

FIGURE 6 is a showing of curves useful in an understanding of the present invention.

In the showing of FIGURES 1, 2 and 3, a thermocouple assembly **11** is shown as formed so that it may be removably clamped to an engine exhaust pipe **12** by means of a steel strap **13** arranged circumferentially of the pipe, the strap having a screw means **14** for tightening the strap and the thermocouple assembly to the pipe **12**. The strap is welded to one end, the lower end, of a tube **16** around an opening in the strap, and to an axially bored stainless steel plug **17** in the lower open end of the tube **16**. The lower end of the plug **17** is coned so as to fit in and close an opening **18** in the exhaust pipe **12**, the plug being positioned and held in the opening by the strap **13** being tensioned around the pipe.

Sealed in the axial bore of the plug **17** is a Chromel metal sleeve **21**. This sleeve extends from the lower ends of the plug and tube a distance which will locate the lower end of the sleeve a desired distance into the exhaust pipe **12**. Inside of the Chromel sleeve **21** is a constantan wire **22** that has its lower end flush with the lower end of the sleeve. The constantan wire is smaller in diameter than the inside of the sleeve, and the sleeve and the wire are spaced and electrically insulated from each other by packing the space there between with a high temperature electrical insulating material, such as powdered magnesia **23**, as this insulating material must continue to function at temperatures in the region of 1700° F. The hot junction element **24**, see FIGURE 3, between the Chromel sleeve **21** and the constantan core **22**, or wire, is formed by a weld that covers and bonds to the end of the wire **22**, bridges the end opening between the wire and the sleeve **21**, and bonds to the sleeve to seal such end opening. This weld, or junction element **24**, is made with a helium shielded arc using a Chromel electrode or a metal having sufficient corrosion resistance. Thus the constantan is sealed from contact with the exhaust gases of the exhaust pipe **12** and there is formed between the Chromel and the constantan a thermoelectric junction. Further, the magnesia powder **23** between the sleeve **21** and the wire **22** insulates them so that contact there between is limited to the outer end junction element **24**.

The upper end of the sleeve **21** extends above the plug **17** a short distance, the wire **22** extends a short distance above the upper end of the sleeve, and the tube **16** extends well above the upper end of the wire. A Chromel lead wire **26** is welded to the Chromel sleeve, and a constantan lead wire **27** is welded to the constantan wire **22**. The Chromel and constantan lead wires are protected by a surrounding insulating material **28**, and the insulated wires and insulation **28** are protected and supported by means of a spiral spring retainer **29** that resiliently grips the exteriors of both the insulator **28** and the tube **16**. The Chromel and constantan electrodes **21**, **22**, their junction **24**, and the two conductors **26**, **27**, and a millivoltmeter **31** are in a circuit **32**. The meter functions so that its indicating range is, preferably, substantially between 1200° F. and 1700° F. The meter is supplied with an electric voltage bucking the voltage obtained from the thermocouple so that the meter does not operate until the beginning of the desired temperature range of indication, for example, 1200° F. to 1700° F. or is supplied

with mechanical suppression obtained by adjustment of the meter spring to obtain such range of indication.

Swaging or drawing of the sleeve **21** after insertion of the wire **22** and the magnesia **23**, packs the magnesia **23** therein. Preferably, the swaging or drawing is so done that the sleeve retains its circular cross section upon reduction of diameter. This is a step in the manufacture of this device that substantially excludes the entrance of air into the sleeve with a resulting reduction in the corrosion of the constantan wire. The addition of high temperature sealant **33** of an electrical insulating type between the upper end of the Chromel sleeve **21** and the constantan wire **22** gives positive assurance that air will not enter the sleeve **21** to contact the constantan wire **22** in the area that it has oxidizive temperatures. The inside of the tube **16** above the lower end-plug **17** is filled with a high temperature insulating material **34** such as magnesia cement, represented by the bracket carrying the reference number **34**. This material extends upward in the tube **16** about three quarters of the distance from the plug **17** to the top of the tube **16**. Inside the tube **16** above the insulating material **34** and inside the spring retainer **29** there is placed a high temperature epoxy cement **35** represented by the bracket carrying the reference number **35**. This cement retains in place the insulator **28** and the lead wires **26**, **27**.

In the modification of FIGURE 4, those parts which are the same or substantially the same as those shown in FIGURES 1, 2 and 3 have been given the same reference numerals as those found and used in such figures. In FIGURE 4, the tube **16** above the plug **17** is filled with insulating material such as magnesia **34** and epoxy cement **35** in the same manner as in the previously described form of the invention. The tube **16** has a slip fit with clamping ferrule **41** that has a wrench boss **42** formed medially thereof with the peripheral portions adjacent each and having tapered threads thereon. The lower end of the tube **16** extends slightly beyond the lower end of the ferrule **41**, and the upper end of the ferrule is spaced from and below the retainer spring **29**. The ferrule **41** is clamped to the tube **16** by a clamp ring **43** that surrounds the tube adjacent its upper end and is internally threaded to match the taper threads of the ferrule. Turning the ring down on the ferrule effects the clamping of the ferrule to the tube. The lower end of the ferrule is screwed into the matching internal threads of a ring boss **44** that is welded to the exhaust pipe **12**. The Chromel sleeve **21** and the constantan core wire **22** extend into the exhaust pipe through the hole **18** in the pipe which is coaxial of the ring boss **44**.

By the construction of either of the described embodiments, the exhaust probe may be easily positioned as shown and removed from such position for servicing. The thermocouple assembly **11** and its circuit **32** are designed to indicate the temperature of the exhaust gases in the exhaust pipe **12** when the fuel-air mixture is varied for the engine with which the exhaust pipe is associated.

While the present disclosure is particular to the use of Chromel as the metal electrode sleeve and constantan as the metal electrode wire, the disclosed construction is applicable to the utilization of other electrode metals for the formation of the hot junction of a thermocouple. Such metals are well known in the art and handbooks. The present invention relates to a construction whereby one metal of a thermocouple may be sealed against corrosion in a simple manner that, also, produces a thermocouple probe of a small mass. This construction, further, results in a thermocouple of high E.M.F. usable at high temperature.

FIGURE 5 is a diagrammatic showing of the disclosed fuel-air ratio control system applied to an engine **51** having an intake manifold **52** which is supplied with a fuel air mixture from a carburetor **53** having a fuel-air ratio adjustment means **54** which is responsive through a control **55**, manual or otherwise, to the temperature

indications of the meter 31 placed in the circuit 32 with the thermocouple assembly 11 that has its probe in the exhaust pipe 12 of the engine 51. By means of the above system, indications of engine exhaust temperature and temperature changes are directly usable to set the fuel-air ratio of the carburetor 53 and of the mixture being supplied to the engine, and to set and maintain such ratio at optimum values as such values change due to changes in engine operation. Such values are maintained because of the disclosed construction.

An understanding of the relationship between exhaust temperature and fuel-air ratio of a gasoline reciprocating-piston engine may be had from a consideration of the curves of FIGURE 6. These curves show the relationship between fuel-air ratio plotted as abscissa; against exhaust temperature at altitudes of 5,000 feet, curve 61, at 10,000 feet, curve 62, and at 20,000 feet, curve 63; against power, curve 64; against fuel economy, curve 65; and against exhaust oxygen, curve 66.

All of the exhaust temperature curves have sharp peaks, and all of these peaks occur at the same fuel-air ratio value, which is the stoichiometric weight ratio of 0.067 for the average gasoline. With the negligible lag between temperature changes in the exhaust and their indication on the meter, it is possible to set the fuel-air mixture by reference to a temperature indication. From the practical standpoint, there are only two fuel-air mixtures that are important in the operation of a reciprocating-piston gasoline engine, best power and maximum economy. It will be noted from curves 61, 62, 63 and 64 of FIGURE 6 that best power occurs when the fuel-air mixture is enriched to cause about a 100° F. drop in exhaust temperature from the peak. At maximum exhaust temperature mixture, the fuel economy is close to maximum (as shown by curve 65) and is considered optimum for cruise operation of unsupercharged engines because at leaner mixtures the power drops off too rapidly. For a supercharged engine where the airflow can be increased to compensate for the drop in power with mixture leaning, the optimum cruise mixture is on the lean side of the exhaust temperature peak by an amount to give approximately a 25° F. drop from the peak. The maximum leaning that is permissible is a function of the uniformity of the fuel distribution among the individual cylinders; the poorer the fuel distribution the closer the point of roughness approaches the peak exhaust temperature. The data in FIGURE 6 is for an engine with good fuel distribution. For an engine with pour fuel distribution, the point of roughness would approach and might reach the point of maximum exhaust temperature.

In FIGURE 6, the curve 66 has the ordinal values shown on the right hand side of the figure as weight percent of oxygen in the exhaust gas. It is desirable to keep the oxygen low in the exhaust to reduce the tendency of the exhaust valves to burn.

In the use of this invention for obtaining the desired fuel-air ratio, while the reciprocating-piston gasoline engine is operating under constant conditions, the mixture is slowly changed, normally from rich to lean, until a peak meter reading is observed. The mixture control is then adjusted to the peak temperature observed if optimum mixture for cruise is desired or is adjusted to enrich the mixture to lower the temperature about 100° F. from the peak temperature if best power is desired. The mixture cannot, however, be leaned to give peak exhaust temperature at power output levels which will give engine detonation, such as may take place at full throttle at sea level.

The relationship between fuel-air ratio and exhaust temperature shown in FIGURE 6 and discussed above holds for all reciprocating-piston gasoline engines for all practical purposes. The fuel-air ratio at which peak exhaust temperature occurs, varies slightly with the carbon-hydrogen ratio of the gasoline, but the maximum economy and best power points remain the same relative to the mixture for peak exhaust temperature.

A specific example of the composition of the Chromel electrode sleeve 21 is: 90% nickel and 10% chromium; and a specific example of the constantan electrode wire 22 is: 60% copper and 40% nickel.

Having thus described my invention, its construction, operation, and use, I claim:

1. A reciprocating-piston gasoline engine, such engine upon operation under constant conditions being characterized by having a maximum exhaust gas temperature that is obtainable by adjustment of the fuel-air ratio of the fuel mixture supplied to such engine during such operation, such engine having in combination therewith a fuel-air ratio control system including a fuel-air ratio adjustment means, and an exhaust gas temperature sensing and indicating means capable of sensing and indicating such exhaust temperature during changes thereof, resulting from manipulation of said adjustment means, so that the time lag of temperature sensing and indication behind temperature change is so small that indication substantially follows change, to enable the fuel-air ratio of said engine to be controlled by setting said ratio adjustment means in accordance with the indications of said indicating means during such operation and change in such ratio.

2. The combination of claim 1 in which such indications deliniate such maximum temperature and such settings are made to give indications in predetermined relationship to such maximum.

3. The method of controlling the fuel-air ratio of a reciprocating-piston gasoline engine having, for the fuel mixture supplied thereto, a fuel-air ratio control system with manually operable means for adjustment of such ratio, such engine upon operation under constant conditions being characterized by having a maximum exhaust gas temperature that is obtainable by manual adjustment of said manually operable means, which method comprises: operating such an engine under constant conditions, while such engine is so operating, manually operating said means for adjustment of such ratio to vary such ratio so as to effect a determination of such maximum temperature, and manually setting said manually operable means in accordance with such determination.

4. The method of controlling the fuel-air ratio of a reciprocating-piston gasoline engine having, for the fuel mixture supplied thereto, a fuel-air ratio control system with manually operable means for adjustment of such ratio between a ratio leaner than and a ratio richer than the stoichiometric ratio, such engine upon operation under constant conditions being characterized by having a maximum exhaust gas temperature that is obtainable by manual adjustment of said manually operable means, and having an exhaust gas temperature sensing and visually indicating means capable of sensing and visually indicating such exhaust temperature during changes thereof resulting from manual adjustment of said manually operable means, the time lag of temperature sensing and indication behind temperature change being so small that indication substantially follows change, which method comprises: operating such an engine under constant conditions, while such engine is so operating, manually operating said means for adjustment of such ratio to vary such ratio and visually observing said indicating means while so varying such ratio so as to correlate such manual operation with such observations to effect indications of temperature rise and fall as the ratio is varied either from rich to lean or from lean to rich, such observations including determination of the maximum temperature indication, and then manually setting said means for adjustment to give a visual indication of an exhaust temperature having a predetermined relationship to such maximum temperature indication.

5. The method of controlling the fuel-air ratio of a reciprocating-piston gasoline engine having a system for

varying the fuel-air ratio of the fuel mixture supplied to such engine to obtain ratios between ratios leaner and richer than the stoichiometric ratio, such engine upon operation under constant conditions, except for variations in its fuel-air ratio, being characterized by having a maximum exhaust gas temperature that is obtainable by adjustment of the fuel-air ratio to the stoichiometric ratio, which method comprises: operating such an engine under constant conditions, while such engine is so operating, determining the substantially instantaneous exhaust gas temperatures of such engine while varying such fuel-air ratio between lean and rich, determining the maximum of such previous determinations, and setting said ratio so that and determining that there is an exhaust gas temperature of a predetermined relative value with respect to such maximum value.

6. The method of claim 4 in which such engine is an airplane engine in flight.

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APPENDIX F

Claim 6 of Hundere U.S. Patent 3,154,060, Written in Independent Form

The method of controlling the fuel-air ratio of a reciprocating-piston gasoline engine of an airplane in flight having, for the fuel mixture supplied thereto, a fuel-air ratio control system with manually operable means for adjustment of such ratio between a ratio leaner than and a ratio richer than the stoichiometric ratio, such engine upon operation under constant conditions being characterized by having a maximum exhaust gas temperature that is obtainable by manual adjustment of said manually operable means, and having an exhaust gas temperature sensing and visually indicating means capable of sensing and visually indicating such exhaust temperature during changes thereof resulting from manual adjustment of said manually operable means, the time lag of temperature sensing and indication behind temperature change being so small that indication substantially follows change, which method comprises:

operating such an engine under constant conditions,

while such engine is so operating, manually operating said means for adjustment of such ratio to vary such ratio and visually observing said indicating means while so varying such ratio so as to correlate such manual

operation with such observations to effect indications of temperature rise and fall as the ratio is varied either from rich to lean or from lean to rich,

such observations including determination of the maximum temperature indication,

and then manually setting said means for adjustment to give a visual indication of an exhaust temperature having a predetermined relationship to such maximum temperature indication.

IN THE

Supreme Court of the United States

OCTOBER TERM, 1975

No. 75-1589

ALCOR AVIATION, INC.,

Petitioner,

versus

RADAIR INCORPORATED,

Respondent.

SUPPLEMENTAL APPENDIX
FOR
PETITION FOR A WRIT OF CERTIORARI TO THE
UNITED STATES COURT OF APPEALS
FOR THE NINTH CIRCUIT

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Oct. 27, 1964 A. HUNDERE 3,154,060

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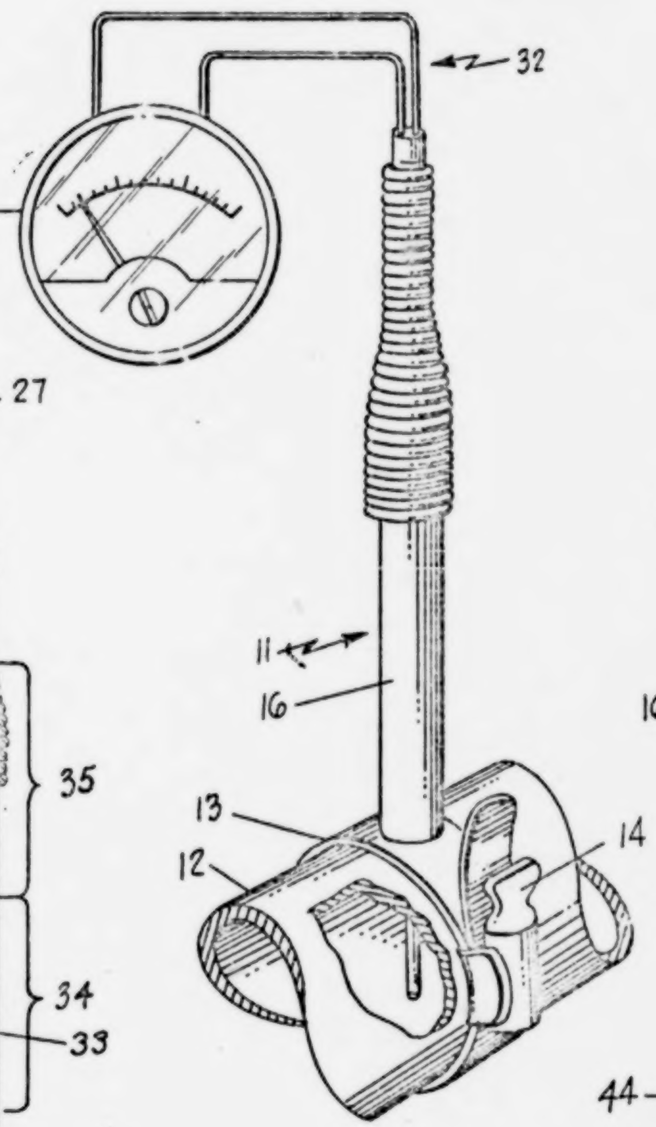

Fig. 1

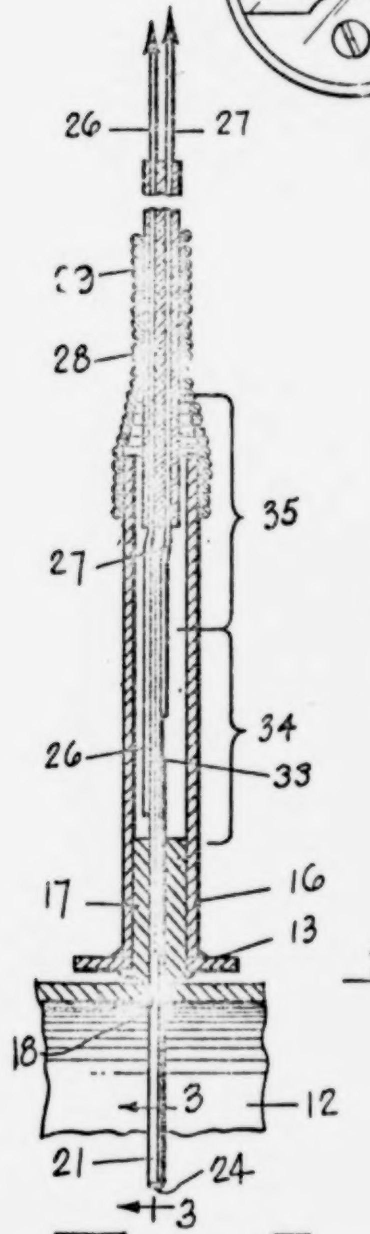

Fig. 2

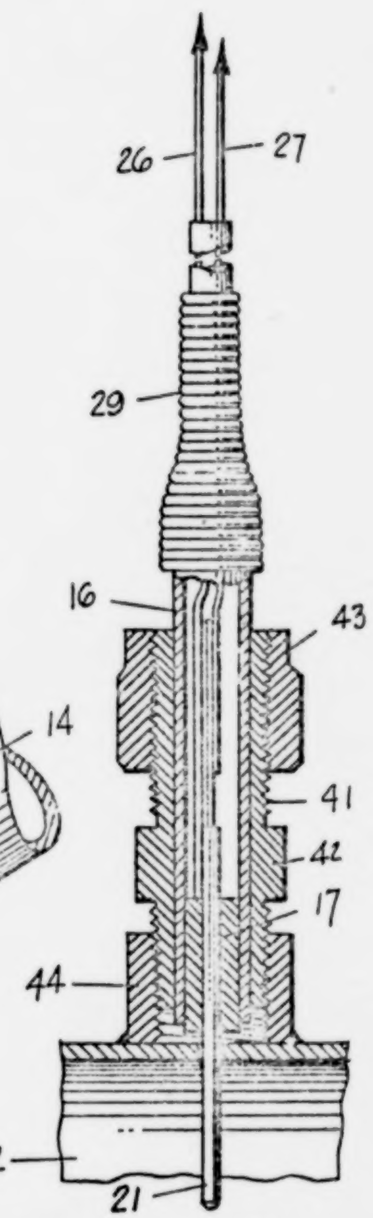

Fig. 4

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RECIPROCATING-PISTON GASOLINE ENGINE FUEL-AIR RATIO CONTROL

Filed Nov. 5, 1962 2 Sheets-Sheet 2

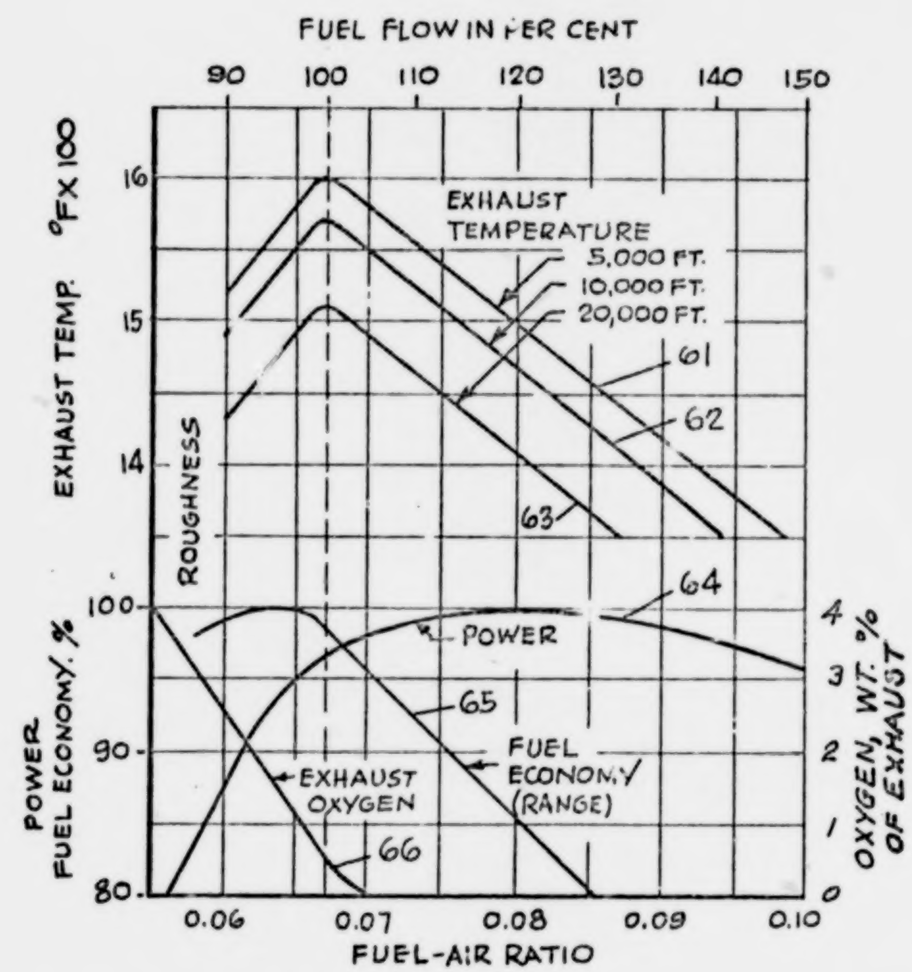

Fig. 6.

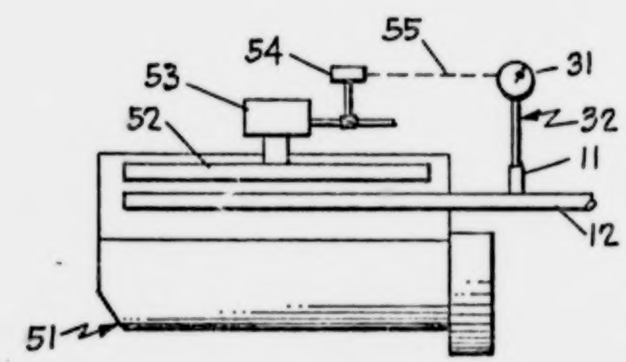

Fig. 5.

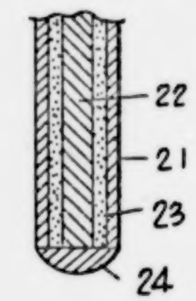

Fig. 3.

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3,154,060
Patented Oct. 27, 1964

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Filed Nov. 5, 1962, Ser. No. 235,430
6 Claims. (Cl. 123—119)

The present invention relates to the control of the fuel air ratio of reciprocating piston gasoline engines. In more particular, the invention relates to a combination of such an engine, its fuel-air ratio adjustment means, and an exhaust gas temperature sensor and indicator for sensing and indicating the temperature of such engine's exhaust gas under operating conditions so that the operator can control the fuel-air ratio in accordance with such indications. Further, the present invention relates to the construction of such sensing and indicating means having such a sensitivity and speed of response that the operator can adjust the fuel-air ratio in a sufficiently short time as needed for improved operation of the engine.

Also, the invention relates to a new method of adjusting the fuel-air ratio of reciprocating piston gasoline engines in accordance with sensitive and rapid indications of the exhaust gas temperature of the engine, and more particularly relates to such a method in which the fuel-air ratio is adjusted in accordance with an indication of the maximum exhaust temperature obtainable by an adjustment of the fuel-air ratio.

In the operation of airplanes not equipped with altitude compensated carburetors, which constitute the vast majority of airplanes in the general aviation category, the fuel-air ratio is controlled in the same manner as on the Model T Ford, that is, manually as a result of the feel and sound of engine operation for the indication of the best mixture of fuel and air. This wastes fuel which on the average, amounts to at least 10% of the fuel used, and, in some cases, it is considerably more. Safety is jeopardized because a mixture that is too lean can cause engine failure from burned valves, and, because, when the mixture is set too rich, as is a common occurrence for a pilot who does not have the proper mixture setting feel, unscheduled landings and crashes can result from the fuel consumption exceeding that anticipated. It has always been recognized that a mixture indicator is needed to eliminate guessing. Exhaust gas analyzers such as the Cambridge analyzer have been available for twenty years or more. These analyzers require a sensing element that responds to change in exhaust gas composition, but these elements are prone to being poisoned by lead from the fuel and other contaminants. The result is that reliability is poor and the maintenance is extremely high. In addition, they have slow response and a very high initial cost. The need for changing settings of the fuel-air adjustment means, in addition to an initial setting, derives from the varying conditions under which an airplane is operated and the need for an optimum fuel-air ratio under each such condition, which ratio is different for each such condition. Such varying conditions are those of power demand and changes in temperature and pressure due either to daily variations or change in altitude.

The present invention particularly further relates to a thermoelectric junction, particularly a hot or temperature sensing junction of a thermocouple having a high sensitivity because of its low thermal inertia and high rate of change in electromotive force (E.M.F.) with change in temperature, together with high resistance to corrosion at elevated temperatures, particularly at the exhaust temperatures of reciprocating piston gasoline engines, such as the range of 1400° F. to 1700° F. An important purpose of the present invention is the development of a thermoelectric temperature sensing junction, a thermo-

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couple probe, that can be used to sense the exhaust temperature changes of reciprocating piston gasoline engines as an aid in fuel-air ratio adjustment for needed engine operation. Such a use requires a fast response to temperature changes, that is, the hot junction probe of the thermocouple must have low thermal inertia. In addition, it must have high output per unit temperature change, millivolts per ° F., in order to obtain high sensitivity. Of available thermocouple materials, Chromel-constantan gives the maximum output per unit temperature change, 45 millivolts per ° F. as compared to 23 millivolts per ° F. for Chromel-Alumel, the conventional thermocouple material for exhaust gas temperature measurement. Constantan, however, can not be exposed to exhaust temperatures without excessive corrosive oxidation. If the Chromel-constantan thermocouple is encased in a protective sheath, such as stainless steel, the mass is increased to thereby increase the thermal inertia. If the constantan is located in a sheath, air must be excluded from entering inside the sheath because at exhaust temperatures the constantan readily oxidizes.

Accordingly, an object of the present invention is the devising of a fuel-air ratio control system for reciprocating piston gasoline engines including an exhaust gas temperature sensor and indicator with negligible lag so that optimum ratios may be obtained and maintained with such speed and sensitivity as to enable improved operation of the engine.

More specifically, it is an object to make a Chromel-constantan thermocouple which will have small mass, hence, low thermal inertia, and high resistance to corrosion.

Also, it is an object of the invention to devise a thermocouple in which a constantan metal portion of the hot junction is protected against corrosion by a Chromel portion of the thermocouple.

It is a further object to devise a thermocouple in which the least corrosive of the two metallic elements of a thermocouple is used to protect the other from contact with a corrosive environment.

Another object of the invention is to devise a thermocouple that has low thermal inertia, high change in E.M.F. per unit temperature change, and resistance to corrosion.

In accordance with a preferred embodiment of the invention, the above-mentioned defects of the prior art fuel-air ratio control systems and thermocouples are remedied and the above objects achieved by the construction of a thermocouple's electrodes in which a Chromel part, or electrode, surrounds and seals a constantan part, or electrode, against corrosion by the use of a constantan wire coaxial of a Chromel sleeve and with wire and sleeve electrically insulated from each other by a refractory material such as magnesia. The contact, the hot junction, the actual Chromel-constantan junction, is formed at the adjacent free ends of the electrodes by fusion thereof by the use of a helium shielded arc using a Chromel electrode or other metal having sufficient corrosion resistance. This insulation is compacted by swaging or drawing the sleeve, and the inboard end of the sleeve is sealed to the core by means of a high temperature sealant. Leads to a meter circuit are joined to the electrodes at their inboard ends. The hot junction and the adjacent lengths of the electrodes constitute a probe which may be inserted in a medium for temperature determinations, when such junction and electrodes are connected in a proper meter circuit.

Embodiments of the device described briefly above are hereinafter described in detail and illustrated in the accompanying drawings, in which:

FIGURE 1 is a perspective view of one form of the

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invention as applied to a section of an engine exhaust pipe with parts of the pipe cut away.

FIGURE 2 is a longitudinal sectional view of FIGURE 1.

FIGURE 3 is an enlarged longitudinal sectional view of the hot junction of either FIGURE 2 or 4 but shown as taken on the line 3—3 of FIGURE 2.

FIGURE 4 is a longitudinal sectional view of a modification of the invention.

FIGURE 5 is a diagramatic showing of the disclosed fuel-air ratio control system applied to an engine.

FIGURE 6 is a showing of curves useful in an understanding of the present invention.

In the showing of FIGURES 1, 2 and 3, a thermocouple assembly **11** is shown as formed so that it may be removably clamped to an engine exhaust pipe **12** by means of a steel strap **13** arranged circumferentially of the pipe, the strap having a screw means **14** for tightening the strap and the thermocouple assembly to the pipe **12**. The strap is welded to one end, the lower end, of a tube **16** around an opening in the strap, and to an axially bored stainless steel plug **17** in the lower open end of the tube **16**. The lower end of the plug **17** is coned so as to fit in and close an opening **18** in the exhaust pipe **12**, the plug being positioned and held in the opening by the strap **13** being tensioned around the pipe.

Sealed in the axial bore of the plug **17** is a Chromel metal sleeve **21**. This sleeve extends from the lower ends of the plug and tube a distance which will locate the lower end of the sleeve a desired distance into the exhaust pipe **12**. Inside of the Chromel sleeve **21** is a constantan wire **22** that has its lower end flush with the lower end of the sleeve. The constantan wire is smaller in diameter than the inside of the sleeve, and the sleeve and the wire are spaced and electrically insulated from each other by packing the space there between with a high temperature electrical insulating material, such as powdered magnesia **23**, as this insulating material must continue to function at temperatures in the region of 1700° F. The hot junction element **24**, see FIGURE 3, between the Chromel sleeve **21** and the constantan core **22**, or wire, is formed by a weld that covers and bonds to the end of the wire **22**, bridges the end opening between the wire and the sleeve **21**, and bonds to the sleeve to seal such end opening. This weld, or junction element **24**, is made with a helium shielded arc using a Chromel electrode or a metal having sufficient corrosion resistance. Thus the constantan is sealed from contact with the exhaust gases of the exhaust pipe **12** and there is formed between the Chromel and the constantan a thermoelectric junction. Further, the magnesia powder **23** between the sleeve **21** and the wire **22** insulates them so that contact there between is limited to the outer end junction element **24**.

The upper end of the sleeve **21** extends above the plug **17** a short distance, the wire **22** extends a short distance above the upper end of the sleeve, and the tube **16** extends well above the upper end of the wire. A Chromel lead wire **26** is welded to the Chromel sleeve, and a constantan lead wire **27** is welded to the constantan wire **22**. The Chromel and constantan lead wires are protected by a surrounding insulating material **28**, and the insulated wires and insulation **28** are protected and supported by means of a spiral spring retainer **29** that resiliently grips the exteriors of both the insulator **28** and the tube **16**. The Chromel and constantan electrodes **21**, **22**, their junction **24**, and the two conductors **26**, **27**, and a millivoltmeter **31** are in a circuit **32**. The meter functions so that its indicating range is, preferably, substantially between 1200° F. and 1700° F. The meter is supplied with an electric voltage bucking the voltage obtained from the thermocouple so that the meter does not operate until the beginning of the desired temperature range of indication, for example, 1200° F. to 1700° F. or is supplied

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with mechanical suppression obtained by adjustment of the meter spring to obtain such range of indication.

Swaging or drawing of the sleeve **21** after insertion of the wire **22** and the magnesia **23**, packs the magnesia **23** therein. Preferably, the swaging or drawing is so done that the sleeve retains its circular cross section upon reduction of diameter. This is a step in the manufacture of this device that substantially excludes the entrance of air into the sleeve with a resulting reduction in the corrosion of the constantan wire. The addition of high temperature sealant **33** of an electrical insulating type between the upper end of the Chromel sleeve **21** and the constantan wire **22** gives positive assurance that air will not enter the sleeve **21** to contact the constantan wire **22** in the area that it has oxidizive temperatures. The inside of the tube **16** above the lower end-plug **17** is filled with a high temperature insulating material **34** such as magnesia cement, represented by the bracket carrying the reference number **34**. This material extends upward in the tube **16** about three quarters of the distance from the plug **17** to the top of the tube **16**. Inside the tube **16** above the insulating material **34** and inside the spring retainer **29** there is placed a high temperature epoxy cement **35** represented by the bracket carrying the reference number **35**. This cement retains in place the insulator **28** and the lead wires **26**, **27**.

In the modification of FIGURE 4, those parts which are the same or substantially the same as those shown in FIGURES 1, 2 and 3 have been given the same reference numerals as those found and used in such figures. In FIGURE 4, the tube **16** above the plug **17** is filled with insulating material such as magnesia **34** and epoxy cement **35** in the same manner as in the previously described form of the invention. The tube **16** has a slip fit with clamping ferrule **41** that has a wrench boss **42** formed medially thereof with the peripheral portions adjacent each and having tapered threads thereon. The lower end of the tube **16** extends slightly beyond the lower end of the ferrule **41**, and the upper end of the ferrule is spaced from and below the retainer spring **29**. The ferrule **41** is clamped to the tube **16** by a clamp ring **43** that surrounds the tube adjacent its upper end and is internally threaded to match the taper threads of the ferrule. Turning the ring down on the ferrule effects the clamping of the ferrule to the tube. The lower end of the ferrule is screwed into the matching internal threads of a ring boss **44** that is welded to the exhaust pipe **12**. The Chromel sleeve **21** and the constantan core wire **22** extend into the exhaust pipe through the hole **18** in the pipe which is coaxial of the ring boss **44**.

By the construction of either of the described embodiments, the exhaust probe may be easily positioned as shown and removed from such position for servicing. The thermocouple assembly **11** and its circuit **32** are designed to indicate the temperature of the exhaust gases in the exhaust pipe **12** when the fuel-air mixture is varied for the engine with which the exhaust pipe is associated.

While the present disclosure is particular to the use of Chromel as the metal electrode sleeve and constantan as the metal electrode wire, the disclosed construction is applicable to the utilization of other electrode metals for the formation of the hot junction of a thermocouple. Such metals are well known in the art and handbooks. The present invention relates to a construction whereby one metal of a thermocouple may be sealed against corrosion in a simple manner that, also, produces a thermocouple probe of a small mass. This construction, further, results in a thermocouple of high E.M.F. usable at high temperature.

FIGURE 5 is a diagrammatic showing of the disclosed fuel-air ratio control system applied to an engine **51** having an intake manifold **52** which is supplied with a fuel-air mixture from a carburetor **53** having a fuel-air ratio adjustment means **54** which is responsive through a control **55**, manual or otherwise, to the temperature

indications of the meter 31 placed in the circuit 32 with the thermocouple assembly 11 that has its probe in the exhaust pipe 12 of the engine 51. By means of the above system, indications of engine exhaust temperature and temperature changes are directly usable to set the fuel-air ratio of the carburetor 53 and of the mixture being supplied to the engine, and to set and maintain such ratio at optimum values as such values change due to changes in engine operation. Such values are maintained because of the disclosed construction.

An understanding of the relationship between exhaust temperature and fuel-air ratio of a gasoline reciprocating-piston engine may be had from a consideration of the curves of FIGURE 6. These curves show the relationship between fuel-air ratio plotted as abscissa; against exhaust temperature at altitudes of 5,000 feet, curve 61, at 10,000 feet, curve 62, and at 20,000 feet, curve 63; against power, curve 64; against fuel economy, curve 65; and against exhaust oxygen, curve 66.

All of the exhaust temperature curves have sharp peaks, and all of these peaks occur at the same fuel-air ratio value, which is the stoichiometric weight ratio of 0.067 for the average gasoline. With the negligible lag between temperature changes in the exhaust and their indication on the meter, it is possible to set the fuel-air mixture by reference to a temperature indication. From the practical standpoint, there are only two fuel-air mixtures that are important in the operation of a reciprocating-piston gasoline engine, best power and maximum economy. It will be noted from curves 61, 62, 63 and 64 of FIGURE 6 that best power occurs when the fuel-air mixture is enriched to cause about a 100° F. drop in exhaust temperature from the peak. At maximum exhaust temperature mixture, the fuel economy is close to maximum (as shown by curve 65) and is considered optimum for cruise operation of unsupercharged engines because at leaner mixtures the power drops off too rapidly. For a supercharged engine where the airflow can be increased to compensate for the drop in power with mixture leaning, the optimum cruise mixture is on the lean side of the exhaust temperature peak by an amount to give approximately a 25° F. drop from the peak. The maximum leaning that is permissible is a function of the uniformity of the fuel distribution among the individual cylinders; the poorer the fuel distribution the closer the point of roughness approaches the peak exhaust temperature. The data in FIGURE 6 is for an engine with good fuel distribution. For an engine with poor fuel distribution, the point of roughness would approach and might reach the point of maximum exhaust temperature.

In FIGURE 6, the curve 66 has the ordinal values shown on the right hand side of the figure as weight percent of oxygen in the exhaust gas. It is desirable to keep the oxygen low in the exhaust to reduce the tendency of the exhaust valves to burn.

In the use of this invention for obtaining the desired fuel-air ratio, while the reciprocating-piston gasoline engine is operating under constant conditions, the mixture is slowly changed, normally from rich to lean, until a peak meter reading is observed. The mixture control is then adjusted to the peak temperature observed if optimum mixture for cruise is desired or is adjusted to enrich the mixture to lower the temperature about 100° F. from the peak temperature if best power is desired. The mixture cannot, however, be leaned to give peak exhaust temperature at power output levels which will give engine detonation, such as may take place at full throttle at sea level.

The relationship between fuel-air ratio and exhaust temperature shown in FIGURE 6 and discussed above holds for all reciprocating-piston gasoline engines for all practical purposes. The fuel-air ratio at which peak exhaust temperature occurs, varies slightly with the carbon-hydrogen ratio of the gasoline, but the maximum economy and best power points remain the same relative to the mixture for peak exhaust temperature.

A specific example of the composition of the Chromel electrode sleeve 21 is: 90% nickel and 10% chromium; and a specific example of the constantan electrode wire 22 is: 60% copper and 40% nickel.

Having thus described my invention, its construction, operation, and use, I claim:

1. A reciprocating-piston gasoline engine, such engine upon operation under constant conditions being characterized by having a maximum exhaust gas temperature that is obtainable by adjustment of the fuel-air ratio of the fuel mixture supplied to such engine during such operation, such engine having in combination therewith a fuel-air ratio control system including a fuel-air ratio adjustment means, and an exhaust gas temperature sensing and indicating means capable of sensing and indicating such exhaust temperature during changes thereof, resulting from manipulation of said adjustment means, so that the time lag of temperature sensing and indication behind temperature change is so small that indication substantially follows change, to enable the fuel-air ratio of said engine to be controlled by setting said ratio adjustment means in accordance with the indications of said indicating means during such operation and change in such ratio.

2. The combination of claim 1 in which such indications deliniate such maximum temperature and such settings are made to give indications in predetermined relationship to such maximum.

3. The method of controlling the fuel-air ratio of a reciprocating-piston gasoline engine having, for the fuel mixture supplied thereto, a fuel-air ratio control system with manually operable means for adjustment of such ratio, such engine upon operation under constant conditions being characterized by having a maximum exhaust gas temperature that is obtainable by manual adjustment of said manually operable means, which method comprises: operating such an engine under constant conditions, while such engine is so operating, manually operating said means for adjustment of such ratio to vary such ratio so as to effect a determination of such maximum temperature, and manually setting said manually operable means in accordance with such determination.

4. The method of controlling the fuel-air ratio of a reciprocating-piston gasoline engine having, for the fuel mixture supplied thereto, a fuel-air ratio control system with manually operable means for adjustment of such ratio between a ratio leaner than and a ratio richer than the stoichiometric ratio, such engine upon operation under constant conditions being characterized by having a maximum exhaust gas temperature that is obtainable by manual adjustment of said manually operable means, and having an exhaust gas temperature sensing and visually indicating means capable of sensing and visually indicating such exhaust temperature during changes thereof resulting from manual adjustment of said manually operable means, the time lag of temperature sensing and indication behind temperature change being so small that indication substantially follows change, which method comprises: operating such an engine under constant conditions, while such engine is so operating, manually operating said means for adjustment of such ratio to vary such ratio and visually observing said indicating means while so varying such ratio so as to correlate such manual operation with such observations to effect indications of temperature rise and fall as the ratio is varied either from rich to lean or from lean to rich, such observations including determination of the maximum temperature indication, and then manually setting said means for adjustment to give a visual indication of an exhaust temperature having a predetermined relationship to such maximum temperature indication.

5. The method of controlling the fuel-air ratio of a reciprocating-piston gasoline engine having a system for varying the fuel-air ratio of the fuel mixture supplied to such engine to obtain ratios between ratios leaner and richer than the stoichiometric ratio, such engine upon operation under constant conditions, except for variations in its fuel-air ratio, being characterized by having a maximum exhaust gas temperature that is obtainable by adjustment of the fuel-air ratio to the stoichiometric ratio, which method comprises: operating such an engine under constant conditions, while such engine is so operating, determining the substantially instantaneous exhaust gas temperatures of such engine while varying such fuel-air ratio between lean and rich, determining the maximum of such previous determinations, and setting said ratio so that and determining that there is an exhaust gas temperature of a predetermined relative value with respect to such maximum value.

6. The method of claim 4 in which such engine is an airplane engine in flight.

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CERTIFICATION OF SERVICE

I, Ted D. Lee, do hereby certify that true and correct copies of the foregoing Supplemental Appendix for Petition for a Writ of Certiorari to the United States Court of Appeals for the Ninth Circuit have been mailed to Benjamin F. Berry, of Seed, Berry, Vernon & Baynham, 1001 Bank of California Center, Seattle, Washington 98162, counsel for Respondent herein, on this the 7th day of May, 1976.

Ted D. Lee

Ted D. Lee